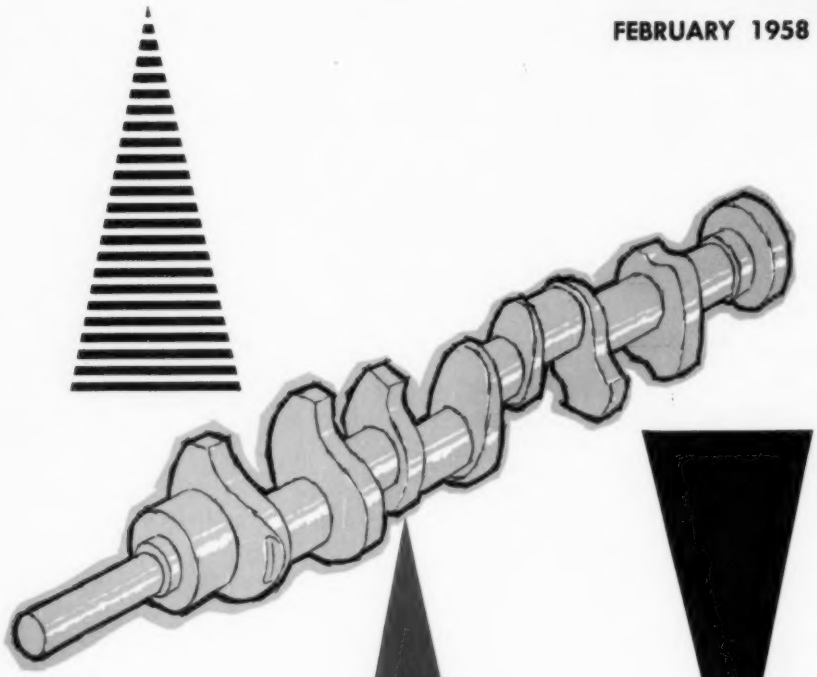
AUTOMATION

FEBRUARY 1958



IN-LINE

Production Balancing

The Magazine of Automatic Operations

- **Guideposts to Automation Planning**
- **Making Tapered Roller Bearings**
- **Magnetic Tape Systems for Data Recording**
- **Applying Transistors**

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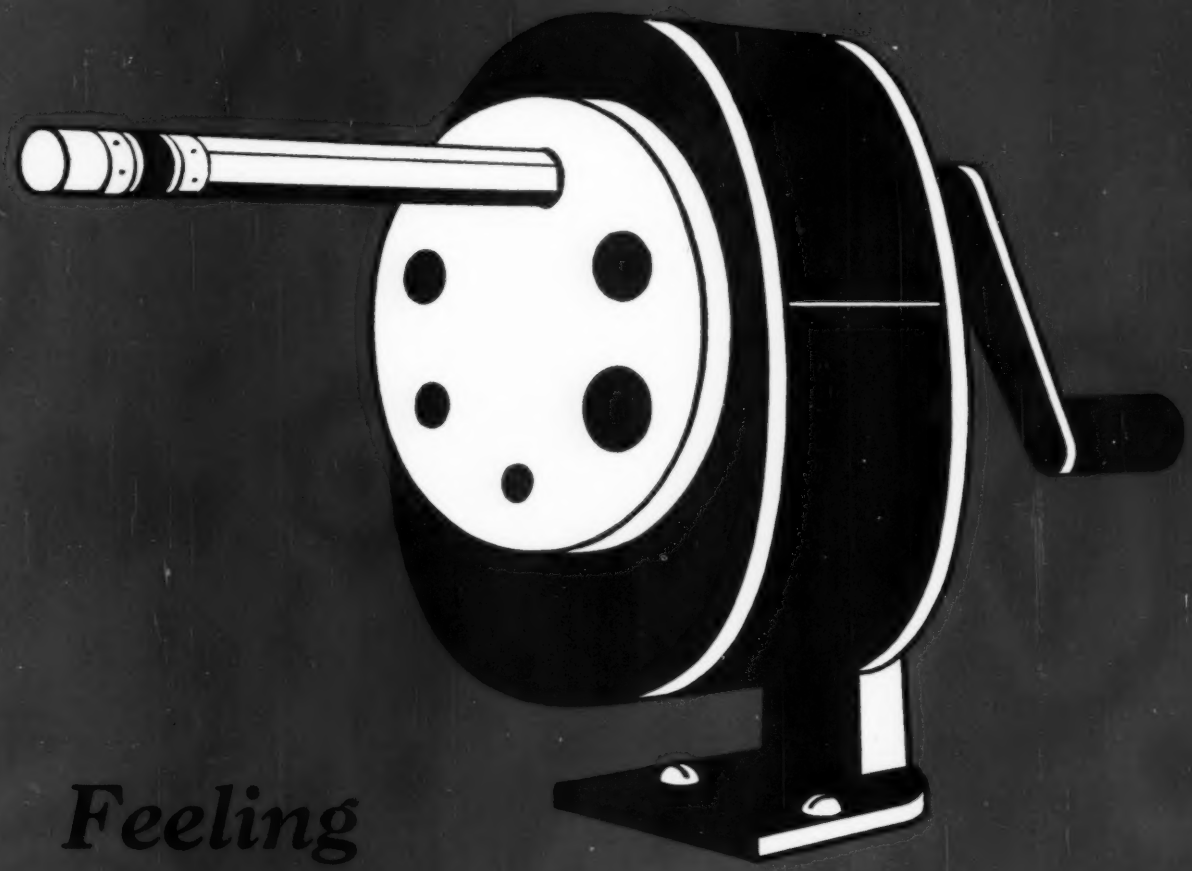

Feeling "profit pinch"?

Circle 651 on Page 17

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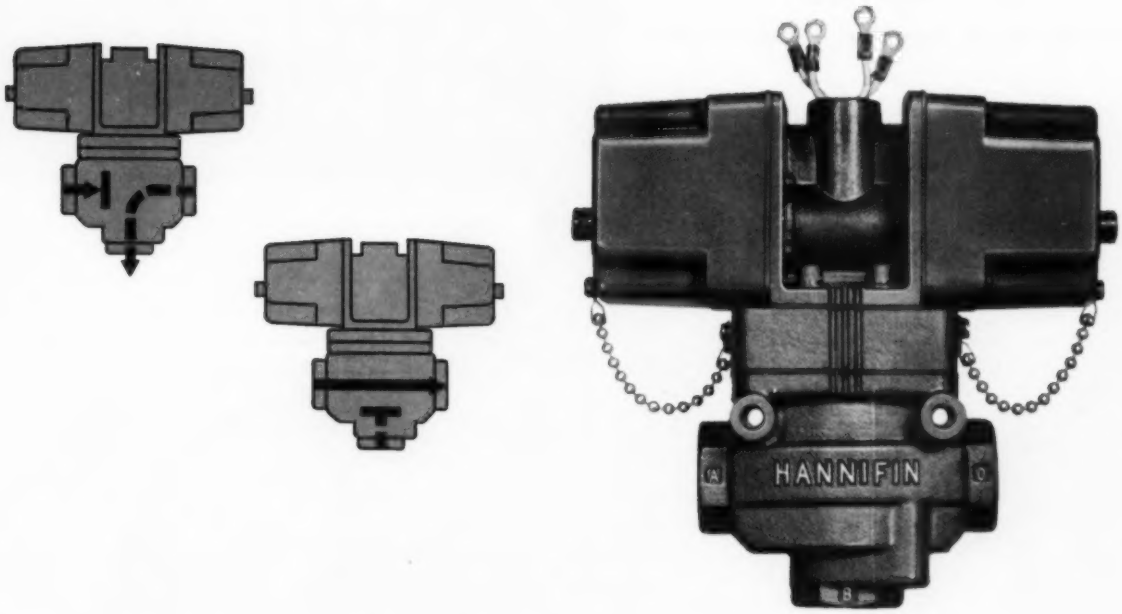
Setting the pace for automation

...Hannifin valves



Automatic processes call for speed, sensitivity and flexibility in directional air control. Above all, they demand dependability. That is why so many valve users find it pays to choose Hannifin.

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VALVES

For this complete catalog showing all the Hannifin directional air control valves, write to Hannifin Company, 541 South Wolf Road, Des Plaines, Illinois. (Hannifin Company is a division of Parker-Hannifin Corporation.)

Circle 654 on Page 17

NOW–CLARK-ENGINEERED adjustable speed drives *IN A PACKAGE*

CLARK "PSC"

(PACKAGED SPEED CONTROL)

For more than 20 years Clark has pioneered in the field of adjustable voltage DC control systems. Since 1934, our company has been a major supplier of specially engineered control for processing lines in the basic metals, rubber and plastics industries, where the advantages of adjustable voltage DC systems have long been recognized.

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"PSC" permits adjusting drive speed over a wide range by controlling motor armature voltage and/or field current. Modifications may be incorporated to adapt "PSC" to an almost limitless variety of applications where controlled-speed DC drives are advantageous.

Illustration shows a modern 3-stand tandem wire flattening mill with the individual stand drives synchronized electrically by Clark "PSC". Compared to similar machines in the same plant with mechanical synchronization, this mill is five times faster with more precise speed and tension control. Thus it holds closer tolerances and reduces breakage of light material.

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FEBRUARY 1958
Vol. 5—No. 2

AUTOMATION

A PENTON PUBLICATION

The Magazine of Automatic Operations

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automation outlook

OPTIMUM DESIGN

". . . in production, the technical future is not a complete enigma since the manager of today has been given a concept which has been shown to be valid in the past, which is expanding tremendously in the present, and which offers a logical answer to anticipated requirements of the future. This concept is automation. As a philosophy, automation encompasses the entire productive effort. It suggests that within the bounds imposed by the economics of a particular situation at any given time, there is an optimum design for a product and its methods of manufacture . . ."—*L. H. Worthman, work simplification supervisor, and J. H. Lemelson, chief methods engineer, U. S. Metals Refining Co., see page 52.*

INSTRUMENTATION PROGRESS

". . . tremendous progress has been made in the field of instrumentation within the past few years. A device which has contributed greatly to this progress—perhaps more than any other device—is the magnetic tape recorder. Through the use of magnetic tape and the magnetic tape recorder, it is now possible to record data in a form which permits automatic reproduction from a transducer to the final form of the data. A phenomenon can be described by the transducer, this intelligence recorded on magnetic tape, and finally reproduced in usable form by automatic means such as time history plots, *x-y* plots and tabulated numerical data . . ."—*Philip A. Mohr, engineering operations section, AGT Div., General Electric Co., see page 72.*

INFLATION STOPGAP

". . . improved increased mechanization would appear to be a necessary part of the braking apparatus that can keep us from spinning into a spiral of uncontrolled inflation . . . Despite the great strides made in lowering some of the costs in manufacture, other factors continue to force higher prices in materials and goods. Without improvements in the manufacturing art and the beginnings of automation, prices would rise even higher and more precipitously. . . "—*Louis Polk, president, The Sheffield Corp.*

EVOLUTION OF STANDARDS

". . . just as the logic of industrial development leads to automation, so the logic of standards leads to a broader system of standards. The smooth transition to an automated economy requires a great extension of the system of company standards, industry wide standards, national and international standards. Automation, in fact, will require a minor revolution on standardization itself . . ."—*Cyril P. Atkinson, assistant professor, engineering design, University of California at Berkeley.*

SUCCESS STORY

". . . electronic premium billing is now a reality at John Hancock Mutual Life Insurance Co., where a large-scale computing system has been quietly carrying out with complete success the paperwork revolution predicted for it. We have already reached an advanced stage of preparation on other applications, which will further streamline processing of the data which is so vital to insurance operations. . ."—*Robert E. Slater, vice president, John Hancock Mutual Life Insurance Co.*

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- NO VACUUM TUBES
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- SAFEGUARDS EQUIPMENT
- SAVES MONEY

The J.I.C. Patented Load Switch is a flexible, direct operating control unit which detects overloads, and prevents damage to drills, reamers, grinders, polishing wheels, presses, conveyors, hoists and hydraulic systems, etc. It will automatically ring an alarm bell, light a visual signal, start, stop, or reverse a motor. It has only two simple adjustments, is compact and easy to install. Send for complete detailed information.

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Circle 656 on Page 17

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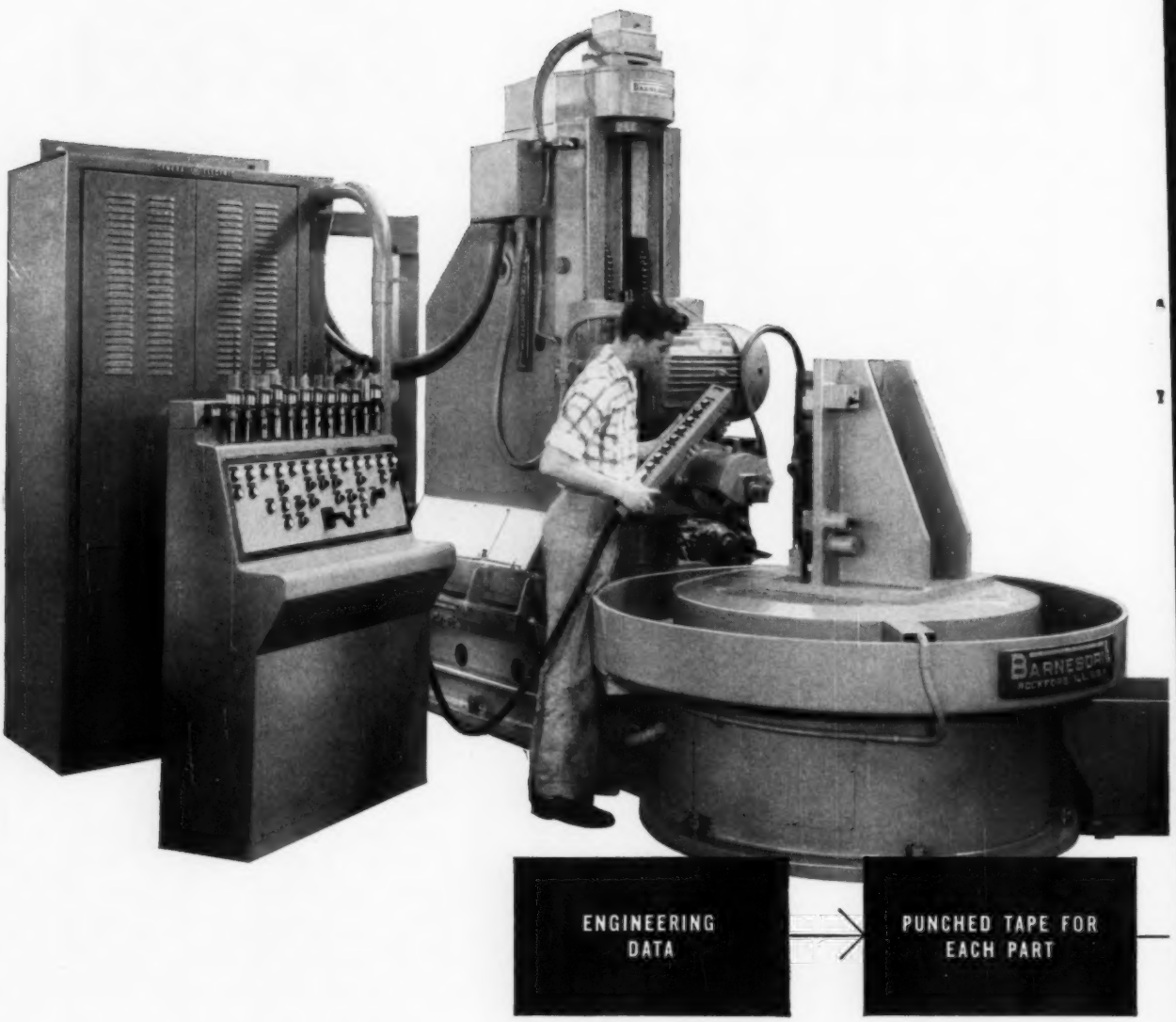


specifications:

248 Operations—
drilling, spotfacing, chamfering

Capacity—
parts up to 36″ O. D. x 30″ long

Spindle Capacity—
drill ¼″ to 1″ in steel,
3″ O.D. x No. 3 Morse Taper

Spindle Travel—
30″, with max. speed of 60 ipm.

Spindle Head—
hydraulic cylinder actuated,
300 ipm. rapid approach,
speeds—as selected by tape
feeds—4-feed rates between 0.5 and 11 ipm.

Rotary Table—
40″ O.D., 1½ HP motor

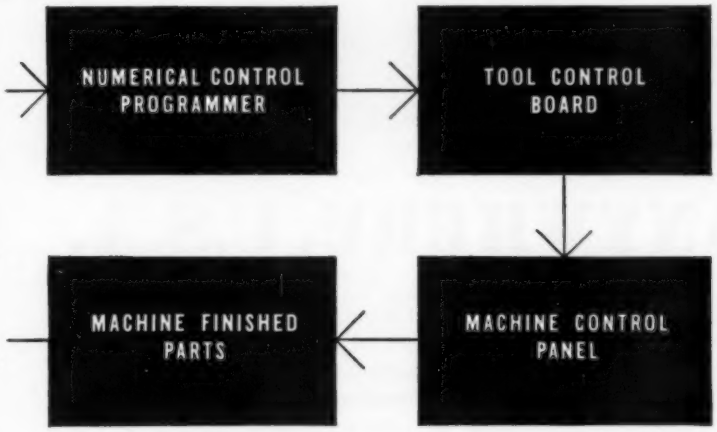
Tools—
13, quick-change type

new BARNESDRIL machine
automatically programs 248 operations
on compressor housings

- **features numerical control by punched tape, unique tool control board**
- **reduces set-up, saves fixturing costs, assures accuracy**
- **solves high-volume, short-run production**

This new BarnesdriL programming machine automatically performs a preselected pattern of operations for machining gas turbine compressor housings, from information stored on standard, business-machine type, punched tape. The pattern is changed at will by substituting a different tape, and the pattern applies to single or multiple plane operations.

A specially designed tool control board integrates the machine programming with the proper sequence of cutting tools, so that the machine will not operate until the correct tool has been selected and placed in the machine, and all others returned after use to their proper places on the tool board. Tools are quick-change pre-set type, selected successively for drilling, boring, reaming, tapping, spotfacing and chamfering.



Information fed back from the machine's movements by means of selsyn motors maintains a constant check on the accuracy of positioning. In actual operation the machine cycles constantly within .003" for true positioning tolerance. Repeatability accuracy is within .001".

With program-type machining, BarnesdriL engineers provide automatically-selected spindle speeds in sequence, according to the best machining practice for the particular operation and kind of material. Feed rates are also programmed to meet the requirements of the part design and machining operation.

Flexibility in type, number and position of operations is obtained by substitution of separate tapes for individual parts to be machined. As a result substantial savings are realized in set-up time and fixturing costs. These are important advantages in high-output, short-run production. Also, with the flexibility inherent in program-machining, the need is eliminated for stock-piling parts.

your inquiries are invited!

BarnesdriL engineers invite your questions and inquiries in connection with production savings involved in program machining for high-output, short-run parts. Send parts or drawings for estimates, or request an engineer to call and discuss these problems in your plant!

50th year

BARNES DRILL CO.

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DETROIT OFFICE: 3419 South Telegraph Road

Circle 657 on Page 17

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Circle 658 on Page 17

AUTOMATION news

Today's events and developments in the field of automation

Numerical Control Adapted To Four-Spindle Boring Machine

NUMERICALLY controlled, four-spindle horizontal boring machine has been developed by Barnes Drill Co. to speed output of jet engine components at the Evendale jet engine plant of General Electric Co. The automatic machine is expected to reduce setup time and machining time on complex jet engine compressor casings by 74 per cent.

The Barnes horizontal boring machine utilizes four spindles selected for four different operations by punched tape. The machine is specifically designed to work on the periphery of cylindrically shaped parts having a maximum diameter of 50 inches and a maximum height of 40 inches. Punched paper tape directs rotary and vertical motions for drilling, spot-facing, boring, reaming, tapping, and chamfering. As many as four different operations can be performed on one specific hole.

The four-spindle boring machine is directed by a two-motion numerical positioning control manufactured by General Electric's Specialty Control Department. Machine operation is programmed on eight-channel tape. The operator initiates the control to read the first block of information on the tape. At the conclusion of the first block of information, the tape reader stops, and the control system takes over. The part is rotated into proper position; the control selects the correct spindle and controls the advance, speed, feed, and depth of cut; selects the appropriate dwell, no-dwell, and backfeed combination; and directs the boring operation.

FOUR-SPINDLE numerically controlled boring machine developed by Barnes Drill Co. performs finishing operations on 248 holes in a jet engine compressor casting. Tape-controlled operation is completely automatic, and requires no tooling change or adjustments by the operator during each machining cycle. The numerically controlled machine is capable of accurate and economical production of duplicate parts and is well suited to the machining of multihole castings requiring a high degree of accuracy.

At the conclusion of the operation, the tape reader resumes reading and initiates the next operation. The completion of the final operation is signaled by a light on the operator's control station. Interruption of the cycle by power failure or emergency stopping does not disrupt the cycle sequence. When power is returned to normal or the emergency condition removed, the operator can continue the cycle at the point of stoppage by pushing a button.

The particular boring machine illustrated is set up to put 248 holes into a compressor casing. The holes are of three different sizes and require three different operations. The operator locates the part in the index table fixture by means of an alignment telescope focused on the casting parting line. Upon the completion of 248 machine operations consisting of finish bore, and generating front face and back counterbore, the operator removes the completed part. At no time during the operation of the machine is the operator required to change tools or make adjustments.

Barnes Drill engineers have conducted many tests on the machine and control device. Test results indicate that the new machine can be expected to reduce setup time and machining time by about 74 per cent. Tooling cost will be held to a minimum since hole size or location change can be accomplished by simple revisions in the

punched tape where fixture changes or replacement were formerly required.

Hitch-Type Feed Mechanism Increases Stamping Output

PRESS FEED arrangement which hitch-feeds material at 2200 to 2500 inches per minute with an accuracy of ±0.005 inch has been developed by Precision Welder & Flexopress Corp. According to the manufacturer, feed strokes up to 36 inches are feasible by the new method.

The new mechanism, called Flexofeed, is used in conjunction with a standard high speed Flexopress using conventional dies. It incorporates a hitch-feed mechanism actuated by a mechanical linkage driven directly from the press. The manufacturer states that the new feed device amounts to a significant break-through in the accepted rate of 1200 inches per minute of accurate stock advancement. Actual production tests have been made running 12-inch wide grain-oriented lamination stock at rates of 2500 inches per minute. Based on a 15-inch feed stroke, the equipment operated smoothly at 165 to 170 strokes per minute while piercing, blanking, and cutting off parts. The hitch-feed fingers averaged speeds of 5000 inches per minute, and accuracy was consistently held to ±0.005 inch.

NEW director of automation for LeMaire Machine Tool Co. is **Lloyd Lee.** Lee is well known in the machine tool field nationally and is a member of the Engineering Society of Detroit and the American Society of Tool Engineers. LeMaire Machine Tool Co. manufactures transfer machines and other automatic high production machining equipment and is broadening its activities to include the design and manufacture of automatic assembly machines. Lee has headed a similar operation at Omer E. Robbins Co. for the past four years.

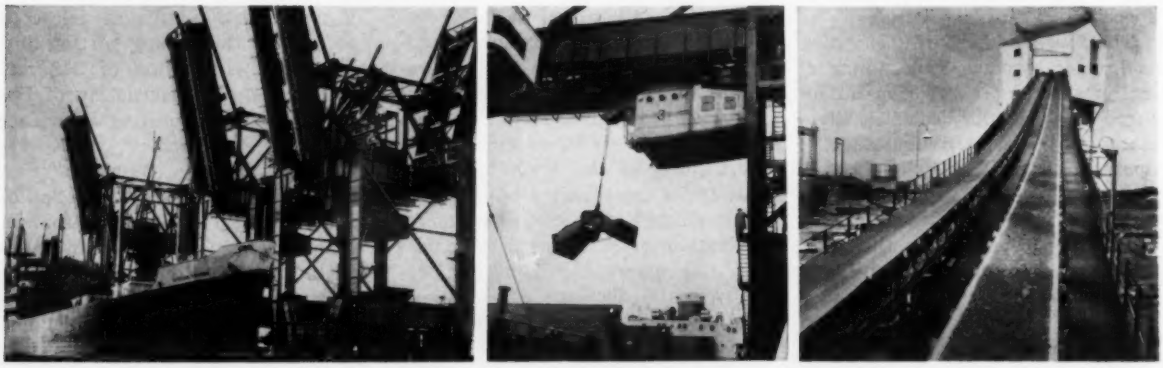
Twisted Magnetic Wire Memory Device Developed

NEW CONCEPT in memory devices has emerged from exploratory work by **A. H. Bobeck** at Bell Telephone Laboratories. This concept, named the "Twistor," is expected to make possible memory systems which are simpler to fabricate and more economical to manufacture than existing systems. Such devices may have extensive applications in computers and electronic switching systems where rapid-access, high-capacity memories are necessary.

The "Twistor" concept opens the way for the construction of magnetic memory arrays by interweaving horizontal copper wires and vertical magnetic wires, much as window screen is woven. Such a device would be similar in appearance to a ferrite core array, but without the cores, and would operate in much the same manner as a core array.

New concept gets its name from a characteristic of wire made of magnetic material. Torsion applied to such a wire shifts the preferred direction of magnetization from a longitudinal to a helical path. The coincidence of a circular and a longitudinal magnetic field can then be used to insert information into this wire in the form of a polarized helical magnetization, and the magnetic wire itself can be used as a sensing means.

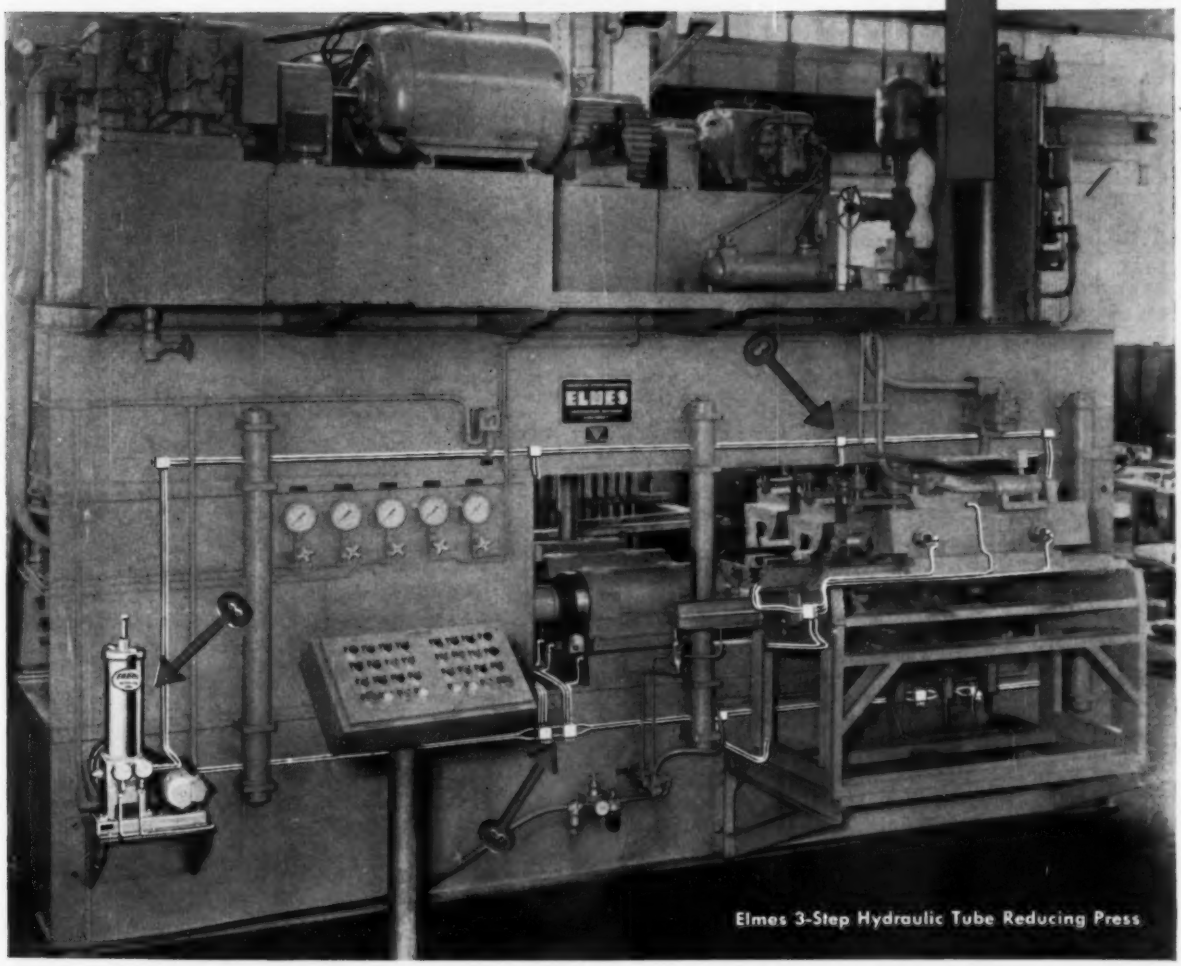
In practice, the circular magnetic field is provided by a current pulse through the magnetic wire, and the longitudinal field by a current pulse through the copper wire perpendicular to the magnetic wire. Storing a bit requires two coincident current pulses. Read-



NEW ORE HANDLING facility has been constructed at Newport News, Va., for the Chesapeake & Ohio Railway. The $8.5 million bulk materials unloading facility embodies the best features of American and European design and is used to unload chrome, manganese, iron, bauxite, and other bulk materials at more than a ton a second. Three 18-ton ore unloaders, left picture, were manufactured by Demag A. G., Duisburg, Germany. They move on rails along the finger-type pier and can work simultaneously on two small vessels or in the holds of a large ship. Ore is picked up by buckets which are detachable and range in size from 80 to 245 cubic feet capacity. Each ore bucket is suspended from a short boom attached to an operator's trolley, center picture. Since the trolley can rotate in a full circle, it is possible to reach almost all points in the ship's hold without repositioning the unloader superstructure. Ore is deposited on either of two 4-foot wide conveyor belts, right picture, for transport to the carloading house located inshore. The carloading house is equipped with modern weighing devices and semiautomatic equipment for loading the ore into two railroad cars simultaneously.

Never a holdup or slowdown to lubricate this tube reducer in Michigan auto factory

FARVAL—
Studies in Centralized Lubrication
No. 203



Elmes 3-Step Hydraulic Tube Reducing Press

●With automation, centralized lubrication is a must. What automated line can afford to slow down or shut down because a forgotten bearing has run dry?

Equipped with Farval, any machine can operate continuously, day and night, with never a pause for lubrication nor a shutdown for a burned-out bearing.

Farval delivers a measured amount of clean oil or grease to every bearing served, at any desired, predetermined interval. No bearing is ever missed—and the amount of lubricant delivered to any one bearing can be varied without affecting the rest of the system. Guesswork and hit-and-miss hand oiling are eliminated with Farval.

A Farval Centralized Lubrication System, manual or automatic, is easily designed into any machine. Let us send a representative to discuss application of Farval to your equipment. Drop us a line. Also ask for Bulletin 26-S. The Farval Corporation, 3265 East 80th Street, Cleveland 4, Ohio.

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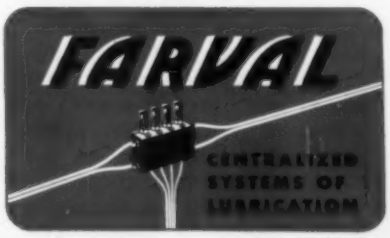
KEYS TO ADEQUATE LUBRICATION—

Wherever you see the sign of Farval—the familiar central pumping station, dual lubricant lines and valve manifolds—you know a machine is being properly lubricated.

This *Farvalized* machine is an Elmes 60-ton Tube Reducer. In three steps it reduces tubing for drive shafts for a well-known Michigan-made automobile.



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out is accomplished by overdriving the longitudinal field in the reverse direction. The readout signal is sensed across the magnetic wire. Because the lines of magnetic flux along the helical path wrap the magnetic conductor many times a favorable increase in the output signal is obtained.

Fool-Proof Bill Changer Handles Dollar Bills

ROBOT CASHIER which will accept a dollar bill and make change automatically has been announced by its inventor, **William A. Patzer,** president of A.B.T. Mfg. Corp., subsidiary of Atwood Vacuum Machine Co. Patzer said the new device will go into production soon and the first models will be available in 1958.

Operating on electronic principles, the bill changer accepts a $1 bill, checks it, and in three seconds returns two quarters, three dimes, and four nickels. The machine can be adapted to dispense other change to fit specific needs and it can be modified to accept currency of other denominations such as $2, $5, or $10 bills.

The robot cashier will accept wrinkled or crumpled money, creased bills, grease-stained bills, torn money, bills that have been written on, and bills inserted upside down or reversed. It will reject bills of larger denominations, foreign currency, and fake money of all kinds. The device will detect and reject bad bills or two valid $1 bills accidentally placed in the machine together.

Revealing that the bill changer is not a scanning device, Patzer pointed out the drawbacks of such an approach. "Scanning devices are expensive to manufacture, difficult to service, and have proved unreliable. Such machines will reject up to 40 per cent of the bills which an average person carries because they are crumpled or creased. To be practical, a bill changing device must accept the kind of currency an average person carries in wallet or purse. It must be simple to operate and must defeat all attempts to defraud it."

Although there are many possible applications for use of the bill changer, it first will be manufactured as a change-making device for food vending machines and telephones in hotels and transportation terminals.

INDUSTRIAL television system for automating complex railroad freight operations has been installed by Radio Corp. of America at a new Atlanta classification yard of the Southern Railway System. Closed-circuit network of ten industrial TV cameras enables clerk at a master control console in a central office to identify freight cars inbound on six different tracks at three entrances to the yard. As a train passes the TV camera, each freight car is televised, allowing the clerk to read and record the identifying initials, number, and type. Each car is then switched for connection to the proper outbound train in the classification yard.

APPOINTMENT of **Niels A. Olsen** as director of the Metalworking Equipment Div., Business and Defense Services Administration, U. S. Department of Commerce, has been announced by BDSA Administrator **H. B. McCoy.**

Olsen has occupied the position of Deputy Director of the division since October 1954. During this period he has worked closely with industry in the development of mobilization and business service programs. Under his direction the division has successfully concluded the first phase of the M-Day Machine Tool Trigger Program. He has also directed extensive surveys and analyses which led to full recognition of thousands of tool and die shops as an industry.

As director of the Metalworking Equipment Div., Olsen is responsible for planning, directing, evaluating, and co-ordinating the programs and activities of the division in carrying out the business services and mobilization planning functions of BDSA as they relate to the products and facilities of metalworking equipment industries.

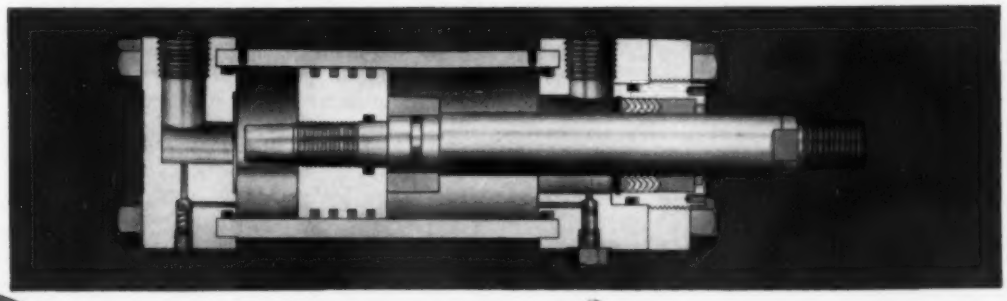
Computer Evaluates Rainfall And Predicts Flood Crests

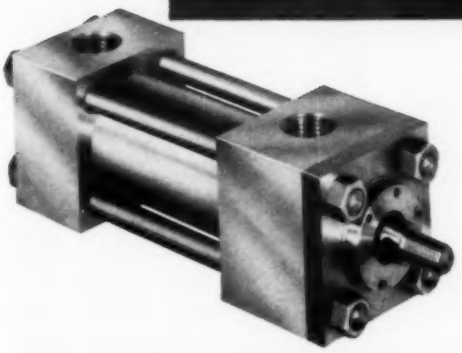
NEW WEAPON in the fight against floods—the electronic computer—is being used by the U. S. Army Corps of Engineers' Ohio River Div. to evaluate the effects of rainfall. Precipitation data is automatically analyzed by the computer, and necessary flood control measures are then initiated.

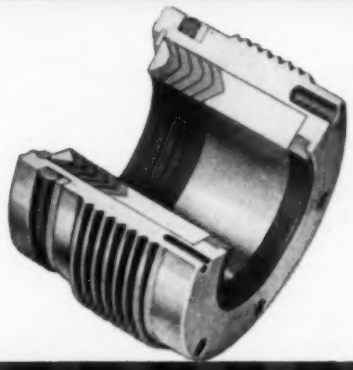
A product of ElectroData Div., Burroughs Corp., the weather-wise computer can solve in five minutes a rainfall problem that would require 75 minutes by manual methods. Major tasks for the computer are what the engineers term "flood routing" and "unit hydrograph computation."

Unit hydrograph computations are used to convert rainfall over a specific area into flow in the stream draining that area. It is a means of determining, from the occurring rainfall and from historic rainfalls, the flow's power. If,

O-M a Power-Full Idea in High Pressure Hydraulic Cylinders







O-M *Series TH*
Heavy Duty Hydraulic Cylinders 2000 PSI Shock Loads 3000 PSI Non-shock Loads Meet JIC Standards

Tested, tried and proved powerful components in today's fast-moving automation picture, these ruggedly constructed O-M Heavy-duty Hydraulic Cylinders breeze through heavy work loads, withstand shocks and strains, and provide smooth, dependable power for a wide range of pressures and operating conditions.

Important design and construction features:

1. Head Seal—"O" Ring with leather back-up washer assures positive seal between head and tube.
2. Heads confine tubing O.D. to prevent breathing and thereby provide additional insurance against leakage under the most severe conditions.
3. Heads are counterbored to pilot in accurately honed tubing to assure perfect alignment.
4. Multiple lip, self-compensating, Vee type rod gland packing.
5. Step-cut ring type pistons are standard, but Vee type pistons are available for holding application.
6. Rod gland cartridge is removable for easy maintenance.

O-M Series TH High Pressure Hydraulic (oil) Cylinders are available in full range of sizes (1½" to 8" bores) with standard and heavy duty piston rods.

Mail Coupon TODAY for Bulletin 105 showing descriptive drawings of cylinders, mounting accessories and capacity chart.

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Circle 660 on Page 17

through their computations, the hydrologists find that a rainfall from a storm or series of storms may produce rivers swollen sufficiently to create flood conditions, the information is relayed to flood control centers where preventive measures are initiated.

Flood routing is a procedure used to compute the advance of a flood wave downstream from point to point, taking into consideration the modifying effects of the channel and the addition of tributary inflow. After being supplied with a mathematical formula, the computer determines the magnitude of a flood at critical locations as the wave moves downstream.

Data Processing Device Tapes Shop Records

DATA PROCESSING device for specialized production information handling has been announced by Control Data Corp. The new recorder is designed to be located in manufacturing or assembly departments where it will accept a variety of information, select and combine pertinent data, and produce a record on punched paper tape, punched cards, or magnetic tape. The resulting information can then be processed through tabulating machines or computers to determine factory payrolls, in-process inventories, production schedules, cost control data, and similar information.

The data recorder is a self-contained unit about the size of a desk calculating machine. Standard production information, such as job number and part number, is fed to the recorder on conventional punch cards. Special employee identification punch cards provide the recorder with an employee's name, pay rate, and other personal information. Variable information such as quantity produced or category of transaction is fed to the recorder through auxiliary inputs from counters or switches and through ten multiposition rotary switches on the console. The standard output medium is eight-level punched tape produced at a speed of 10 characters per second. Punched cards or magnetic tape will also be available as an output medium.

The flexibility of the recorder is further expanded by a number of accessory units which can provide different levels of information in varying forms and make possible the grouping of many recorders into a complete data processing system. The new recorder is designed to eliminate much of the time-lag and errors inherent in conventional methods of processing production information.

Testing Device Speeds Steel Coil Checking

TESTING time for incoming coils of high carbon steel wire has been substantially reduced at Ramset Fastening System, a division of Olin Industries. By using a metal monitor test instrument developed by Brush Electronics Co., a division of Clevite Corp., coils are checked electronically in seconds and a two-hour heat treat and hardness test procedure has been eliminated.

Ramset exercises a careful check on incoming raw materials to prevent mixing high carbon steel coils, used in the manufacture of driving pins and studs for penetrating steel and concrete, with low carbon steel coils used in other products. Up to two hours a day were formerly spent by an inspector in checking coils by the heat treat and hardness test procedure. Incoming coils are now checked with the metal monitor instrument in a few seconds.

The Brush metal monitor is a self-contained, portable unit designed to be used by shop personnel with limited operational instructions. It operates on the principle of comparing thermoelectric voltages generated between two electrodes and the metal under examination. A range switch allows selection of measurement sensitivities to reveal minute differences in a metal's chemical and/or physical properties.

DESCRIPTIVE literature which describes power transmission belting made of polymer and chrome tanned leather is available from Extremultus Inc. The belt consists of layers of leather and textile between which are sandwiched lay-

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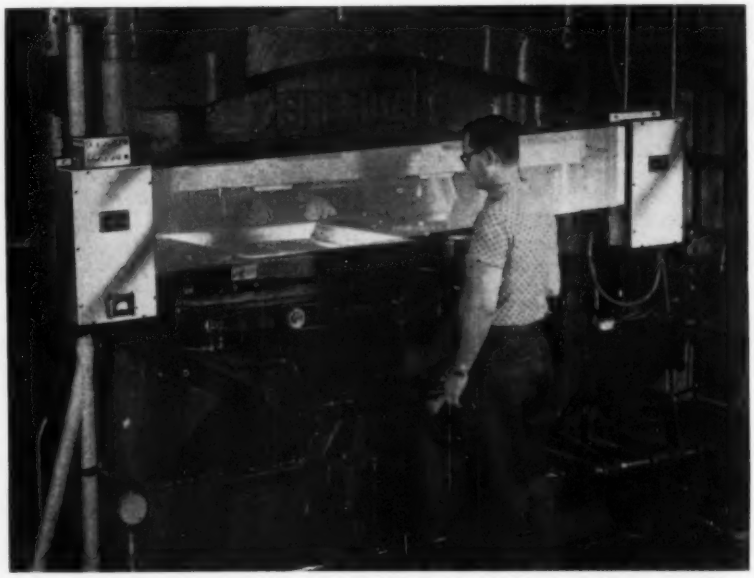
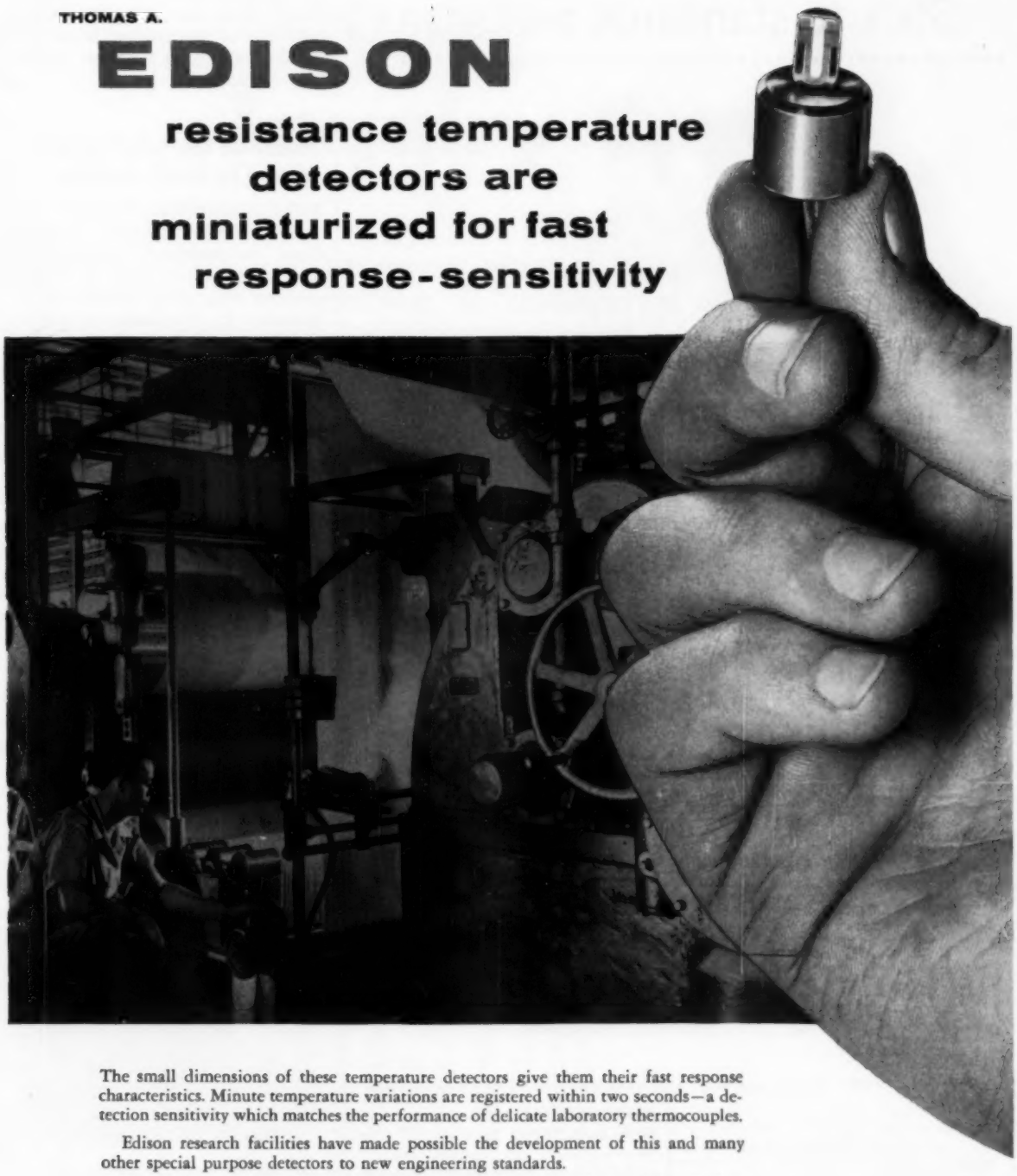


BEAM OF LIGHT press guard has been developed by Electronic Control Corp. to automatically control the operation of hydraulic and friction-clutch machines. The light curtain is available in heights up to 18 inches and will stop a press when broken at any place by an operator's hand. The press can also be tripped automatically when the operator's hand has been withdrawn to a safe position. The equipment is reported to be fail-safe in that the press operates as long as the light beam is in working order. Should any part of the unit fail or power be cut off, the press automatically stops.

THOMAS A.

EDISON

resistance temperature detectors are miniaturized for fast response-sensitivity



The small dimensions of these temperature detectors give them their fast response characteristics. Minute temperature variations are registered within two seconds—a detection sensitivity which matches the performance of delicate laboratory thermocouples.

Edison research facilities have made possible the development of this and many other special purpose detectors to new engineering standards.

Designed to measure oil film temperatures, these units have been miniaturized to the point where they can be positioned in direct contact with bearing oil film in a wide variety of applications.

For complete information on Edison Resistance Temperature Detectors, write for Bulletin No. 3016.

Thomas A. Edison Industries
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McGRAW EDISON

Circle 661 on Page 17

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( ) Standard index tables

ers of polymer. The polymer tensile member adds strength and absorbs shock loads. Proper selection and use of the belting is covered in the catalog in addition to typical applications.

Numerical Controlled Systems Offered By Bendix Aviation

ESTABLISHMENT of a new controls section of Bendix Aviation Corp. to engineer, manufacture, and sell tape-controlled production systems has been announced by **Malcolm P. Ferguson,** president. The new operation will be headed by **George S. Knopf,** formerly executive engineer of Bendix Research Laboratories.

Bendix will design and build completely automated systems, including associated electronic equipment and drives, to control machine tools in all cutting functions. Tape preparation and other engineering services will also be supplied to manufacturers and to the machine tool industry.

The aircraft industry, the machine tool industry, and manufacturers of dies for forgings, die castings, and sheet metal parts probably will be the first big market for tape-controlled boring and milling systems, Ferguson said. He

MINIATURE automation is used to produce tiny semiconductor products at Sperry Semiconductor Div., Sperry Rand Corp. In sealed rooms, precision production machines perform microassembly operations on 17 types of silicon diodes which are so small that several dozen are required to fill a thimble. Assembly operations include alignment and joining of speck-size internal parts, capsule atmosphere control, heat focusing, and final sealing of the semiconductor's tiny glass capsule. The series of operations is started by pushbutton and is completed in 27 seconds.

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419	449	479	509	539	569	599	629	659	689	719	749	779	809
420	450	480	510	540	570	600	630	660	690	720	750	780	810
421	451	481	511	541	571	601	631	661	691	721	751	781	811
422	452	482	512	542	572	602	632	662	692	722	752	782	812
423	453	483	513	543	573	603	633	663	693	723	753	783	813
424	454	484	514	544	574	604	634	664	694	724	754	784	814
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427	457	487	517	547	577	607	637	667	697	727	757	787	817
428	458	488	518	548	578	608	638	668	698	728	758	788	818
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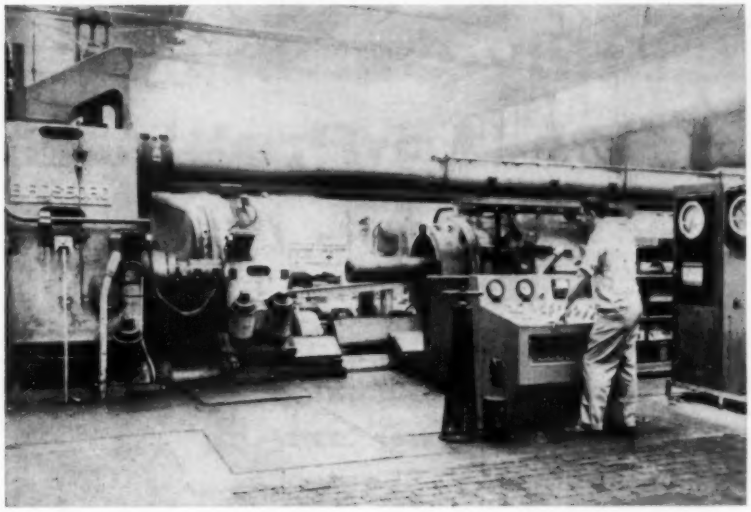

AUTOMATICALLY sequenced water-hydraulic extrusion press is now in operation at Kaiser Aluminum & Chemical Corp., Halethorpe, Md. The press was designed and built by Birdsboro Steel Foundry & Machine Co. to extrude a broad range of aluminum tube sizes and assorted shapes. Main ram of the press exerts a force up to 3500 tons. The maximum force of the mandrel piercer is 250 tons. The ram, mandrel piercer, container, gate locks, and shear are actuated by water at 4250 psi while the billet loader and die carrier are actuated by oil at 750 psi. The press is designed to be operated automatically or manually and can extrude billets 9 to 12 inches in diameter and up to 36 inches long.

also saw the new automated manufacturing system as having special benefits for many small businesses where tooling costs are high and cannot be absorbed by long production runs.

Changes In Labor Force Cited in Survey

AUTOMATION is contributing to changes in the structure of the labor force in American industry according to a report prepared by the National Industrial Conference Board after a survey at 130 companies.

The Conference Board study found that: 1. The proportion of workers engaged in direct production labor has declined during the past three years. 2. The proportion of workers in the factory indirect labor force—such as maintenance, production control, and security—also has dipped since 1954. 3. These shifts in the labor force are accompanied by proportionate increases in nonfactory employment such as office, clerical and sales personnel.

The addition of new and improved equipment in production departments was the most important single factor cited as having contributed to the shift from direct labor to jobs not directly involved with actual production. Other reasons cited in the study include: Expansion of business volume; keener competition; development and introduction of new products; decentralizing of company operations; and additional reports required by governmental agencies, trade associations, and plant and office supervisors.

Automated Laboratory Devices Increase Research Productivity

AUTOMATION of many routine procedures used in scientific research is the purpose of a new firm, Instruments for Industry and Research, headed by **Daniel R. Conlon,** former research specialist with Rohm & Haas Co. The firm has started production of three types of automated laboratory instruments and is testing prototypes of other mechanized equipment.

The new devices are small, low-cost, light-weight electronic units designed to automatically control many variable operations which now require close scrutiny for long periods of time by research workers. One instrument now in pro-

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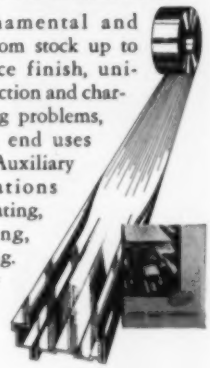

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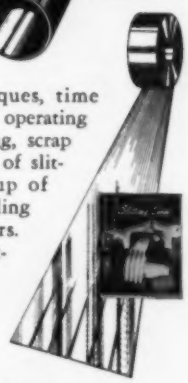
Operating techniques, time studies, analyses of operating cycles, coil handling, scrap disposal, selection of slitters and setting up of slitting lines, including coilers and recoilers. Advantages of slitting and how to compute "profit-point". 76 pages, fully illustrated.



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Circle 663 on Page 17

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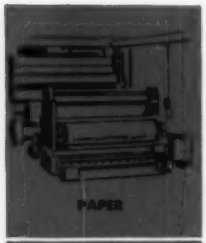

If you want to Drive, Stop, Test—Control Speed, Torque, or Tension — Dynamatic Equipment will do it Better at Lower Cost!

Dynamatic Eddy-Current Couplings, Drives, Brakes, and Dynamometers—

fulfill practically all stepless adjustable speed and testing equipment requirements, using standard alternating current as a power source. This Dynamatic torque transmitting equipment, with electronic or magnetic amplifier control, offers a long list of outstanding advantages: rapid response, wide speed range, quiet operation, low power loss, low maintenance cost, and remote control. There are types and sizes of Dynamatic Eddy-Current Equipment for every industrial requirement, including compact drive-package combinations *(illustrated at the right)*.

Dyna-torQ Magnetic-Friction Clutches, Brakes, Clutch-Brakes, and Clutch-Couplings—

provide the accurate trouble-free method of controlling power and motion in modern stop-and-go machines. Eaton Dyna-torQ units utilize a simple operating principle which provides instant response, shockless acceleration and deceleration. Superior construction means long operating life, minimum down-time, low maintenance cost. Outstanding advantages include rapid engagement and disengagement, self adjustment, lower operating temperature through effective cooling, simple accurate control. There is a wide range of sizes and capacities.

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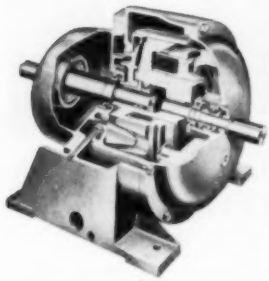
Dynamatic Eddy-Current and Dyna-torQ Equipment

Magnetic-Friction Equipment is in Every Major Industry

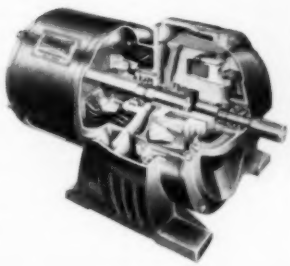


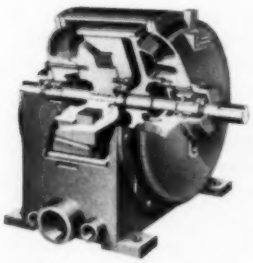
EDDY-CURRENT COUPLINGS

Dynamatic Eddy-Current Couplings transmit torque from driving to driven member without mechanical contact, shock, or friction. Controls provide infinitely adjustable speed from a constant speed source or constant speed from a variable speed source with smooth, controlled acceleration. Liquid-cooled and air-cooled types.

EDDY-CURRENT DRIVES

Dynamatic Eddy-Current Drives consist basically of an integral combination of an AC constant speed induction motor and an eddy-current coupling. Electronic or magnetic amplifier control provides accurate speed control for a wide range of applications. Available in liquid-cooled and air-cooled types.



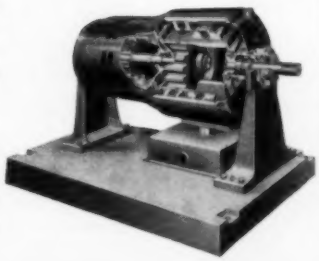


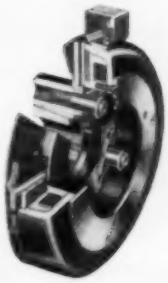
EDDY-CURRENT BRAKES

Dynamatic Eddy-Current Brakes are available in a wide range of torque capacities and operating speeds. Features include smooth, frictionless, shock-free operation with no rotating electrical components or contacts. Liquid-cooled and air-cooled types.

EDDY-CURRENT DYNAMOMETERS

Three types of Dynamatic Eddy-Current Dynamometers are available to meet various testing requirements; absorption dynamometers up to 15,000 HP; motoring or driving dynamometers up to 500 HP; and universal dynamometers to 500 HP and larger. Special purpose dynamometers are also available.



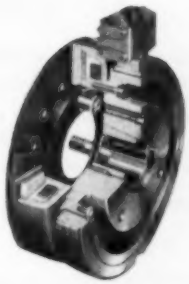


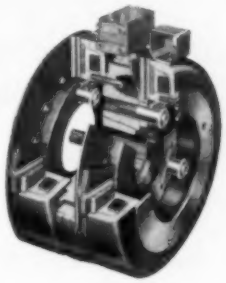
DYNA-TORQ BRAKES

Dyna-torQ Brakes provide controlled deceleration and positive stop with a touch of the control. Rapid, shockless stopping of rotating machine parts reduces interval between operations, and positive holding keeps them motionless between cycles. Compactness and remote control mounting conserve space.

DYNA-TORQ CLUTCHES

With the Dyna-torQ Clutch close control of clutch torque provides soft, cushioned starts, minimizing shock. Driving motors may be brought to operating speed before coupling to the load. Soft clutching permits controlled acceleration.



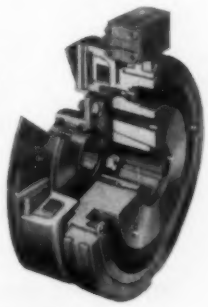


DYNA-TORQ CLUTCH-BRAKES

The Dyna-torQ Clutch-Brake provides closely controlled acceleration and deceleration. It is ideal for applications requiring automatic start-stop operation, eliminating time loss in slow-down between operations, and facilitating accurate automatic cycling.

DYNA-TORQ CLUTCH-COUPLINGS

Compact, simple, Clutch-Coupling parts are installed on shaft ends in the same manner as the halves of a conventional flexible coupling. Designed for clutching of directly-aligned shafts, the Dyna-torQ Clutch-Coupling is easily installed on existing machinery or designed into new equipment.



DYNAMATIC DIVISION
EATON MANUFACTURING COMPANY
KENOSHA WISCONSIN
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METALS

BUSINESS MACHINES

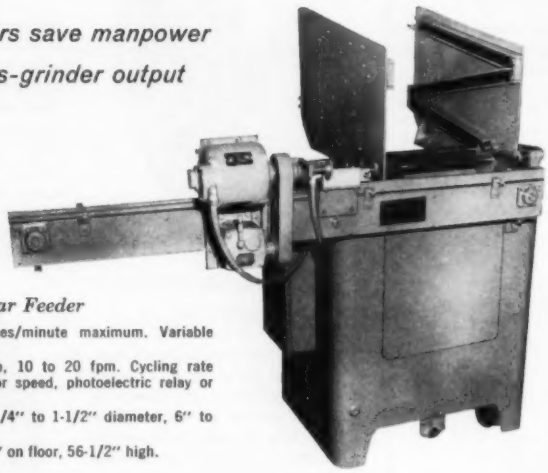
TESTING

another automation idea from Feedall

CUT COSTS WITH

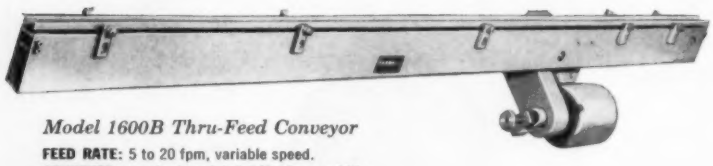
Feedall

- *automatic feeders save manpower*
- *speed centerless-grinder output*



Model 1700B Bar Feeder

FEED RATE: 90 pieces/minute maximum. Variable speed drive.
BELT SPEED: variable, 10 to 20 fpm. Cycling rate controlled by conveyor speed, photoelectric relay or mercury switch.
RANGE: feeds parts 1/4" to 1-1/2" diameter, 6" to 26" in length.
SPACE: 24" x 65-1/2" on floor, 56-1/2" high.



Model 1600B Thru-Feed Conveyor

FEED RATE: 5 to 20 fpm, variable speed.
CONVEYOR: standard model, 1-3/4" frame width.
RANGE: feeds parts 1/4" to 2-1/4" diameter, up to 62-1/4" in length.
DRIVE: 1/4 hp, three phrase, 220-440 volts.

Eliminate operators! Feedall's "complete-package" feeders simply drop in place — production starts in seconds. Work-pieces move in continuous flow into centerless grinders automatically — at speeds far exceeding manual output.

The secret is Feedall's multi-million cycle dependability, assured by careful engineering and proved operation with specified action. And, Feedalls are adaptable: feeding rolling or sliding parts in a broad range of lengths and diameters, for almost any standard or special production machine or process.

Interesting details are available in latest catalog. Write for your copy today — or send us brief data and sample parts for prompt reply.

Feedall *Producers of automatic feeding devices*
FEEDALL, INC., WILLOUGHBY, OHIO

ELEVATING, BLADE, TUMBLE, VIBRATORY FEEDERS • TRANSFER AND ELEVATING CONVEYORS • SPECIAL SELECTOR DEVICES

VILLANOVA electrical engineering student is shown automation facilities at General Electric Company's Light Military Electronic Equipment Dept. in Utica, N.Y. The student, William G. McNeill Jr., left, views a tape-programmed automatic punch press in the company of George Dieffenbacher, GE engineer. McNeill became interested in the automation techniques through reading an article in the company magazine. General Electric feels encouragement of engineering interest in automation on the student level is healthy for education and for industry. Special tour was arranged to help the student formulate better ideas of automation practices.

duction has a small electronic element which clips onto a thermometer or manometer and converts it into a temperature or pressure regulator. Another instrument uses a thermocouple to monitor the temperature of a solution. A third instrument automatically raises and lowers heating and cooling devices at the direction of one of the other devices. These units are the first of several "building blocks" which the company plans for automation of a wide variety of laboratory operations.

The instruments are designed to relieve the scientist of many routine procedures which consume up to three-fourths of his time in the laboratory. As the researcher is freed from more of these tedious jobs, he is able to devote more time to the creative aspects of his work.

International Exhibition Held In Dusseldorf

INTERNATIONAL Congress and Exhibition of Measuring Instruments and Automation, known as INTERKAMA, was held in November in Dusseldorf, Germany and

had an attendance of 80,000 trade buyers and specialists. Over half of the visitors came from foreign countries and 3000 scientists and engineers from 65 countries took part in the congress and the technical sessions.

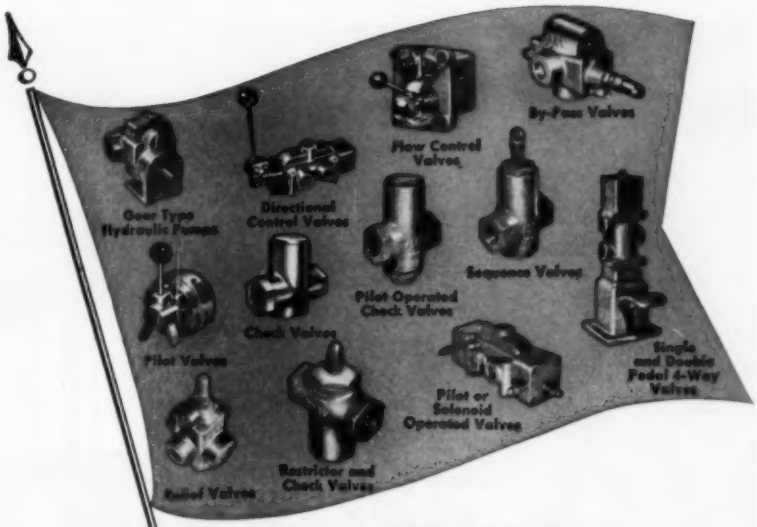
A large variety of modern appliances, instruments, and installations used in the fields of measuring, controlling, and automation were displayed by 331 exhibitors, 40 per cent of whom were foreign manufacturers.

Engineers Share Patent Award For Steel Mill Control System

FOUR ENGINEERS of the Westinghouse Electric Corp. have received $2500 each for developing a control system that permits production of strip steel at speeds in excess of 6000 feet per minute. Those honored were **Raymond W. Moore, William D. King, James T. Carleton,** and **Loren F. Stringer.**

The control system is based on use of magnetic amplifiers which in effect reduce duration of control reactions from four seconds to one-tenth of a second. In addition to split-second response to load variations, the system is said to demonstrate higher regulating ac-

EXPERIMENTAL device that can read handwritten numerals has been developed by Bell Telephone Laboratories. The machine recognizes numbers as they are being written and indicates the numeral by lighting up the correct digit on a numbered panel. Writing is done with a metal stylus on a specially-prepared surface. Two dots, one above the other, are used as reference points. Seven sensitized lines extend radially from these dots, and numerals are recognized by the machine, depending on which lines are crossed. The device can also read from numerals written on paper and inserted behind the sensitized plate. Such information could be transferred to an accounting machine, computer or other data processing device.



BY ANY STANDARD...

ADEL *Refinements* assure Plus Performance for Your Equipment

Designers and Engineers have set these standards for Industrial Hydraulic Equipment

Rugged simplicity • Long life • Simplification of piping • Reduced installation costs • Greater accessibility for maintenance • Completeness of line • Over-all economy

ADEL brings them all to you!

Smooth economical hydraulic power for Pushing, Pulling, Lifting, Pressing, Clamping and Controlling.

Illustrated are but a few of a wide variety of ADEL industrial hydraulic control equipment that offer definite benefits to both the user and builder of machine tools and many other kinds of equipment. ADEL products incorporate proven design and precision construction features that assure dependable operating efficiency over the years. A complete line for every application. You can simplify your Hydraulic Power Motion Problems by specifying ADEL.

For complete engineering specifications and counsel, Address: ADEL PRECISION PRODUCTS, Huntington 4, West Virginia

Reliability ADEL PRECISION PRODUCTS
A DIVISION OF GENERAL METALS CORPORATION

HUNTINGTON, WEST VIRGINIA

Manufacturers of MARINE & INDUSTRIAL HYDRAULIC CONTROL EQUIPMENT

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UTAH
Robert Taylor & Sons
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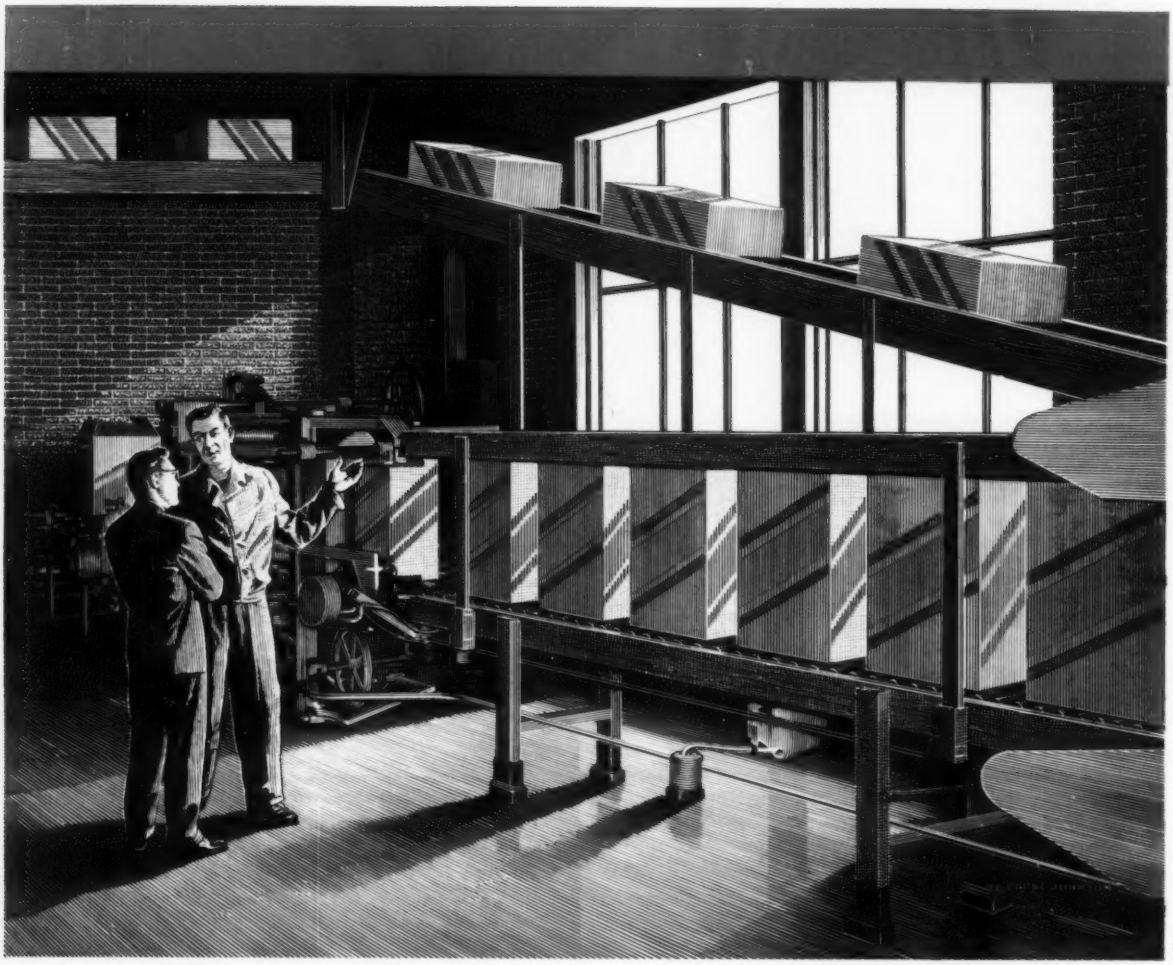
WASHINGTON
Russ Chamberlin Company
Seattle, Washington

Circle 666 on Page 17



PACKAGING PLANNED FOR AUTOMATION

A single "off-size" box can halt your automated production line. Stay in the clear with Gaylord boxes. Precision-made of quality materials—they're your best choice for smooth, uninterrupted package flow.

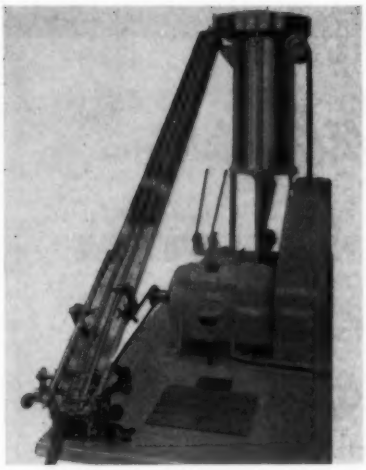
Whether your operations are fully or semi-automated, Gaylord boxes help keep you profitably on the move. Contact your nearby Gaylord packaging engineer.

Gaylord Boxes

CORRUGATED AND SOLID FIBRE BOXES • FOLDING CARTONS • KRAFT PAPER AND SPECIALTIES • KRAFT BAGS AND SACKS

GAYLORD CONTAINER CORPORATION ★ ST. LOUIS

DIVISION OF CROWN ZELLERBACH CORPORATION



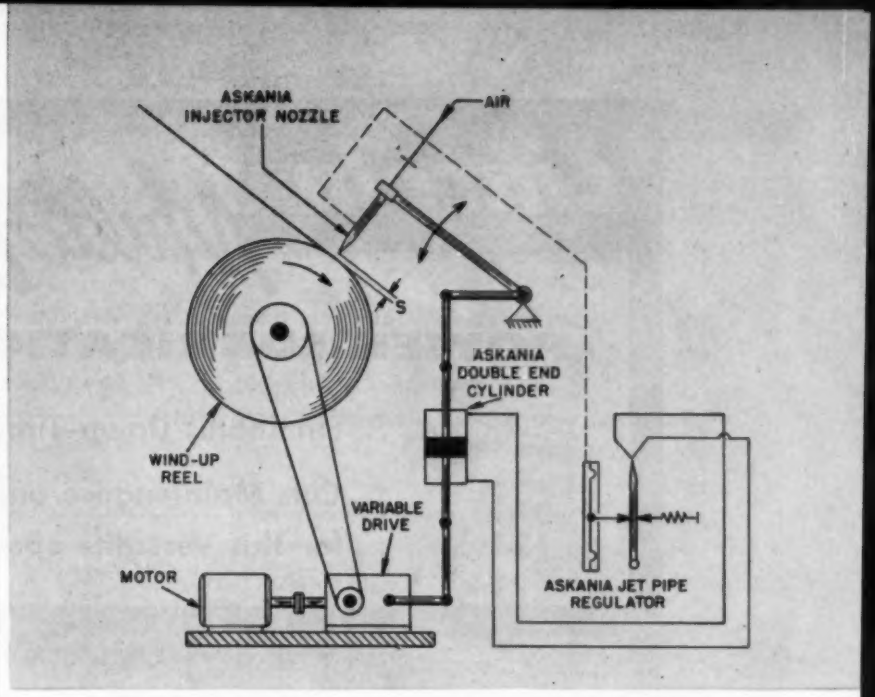
HIGH-SPEED tablet and capsule counter is specially designed for fast, accurate counting and filling of quantities such as 100s, 500s, and 1000s. Built in West Germany, the Rotax counter is imported and distributed by Burnet Co. Although originally designed for the pharmaceutical industry, the counting machine is easily adaptable to other fields requiring rapid, accurate count such as ball bearings, beads, curtain rings, and candies. The model shown is capable of counting approximately 180,000 units per hour.

curacy than any previous control method. Its speed, reliability, and accuracy have permitted higher rolling speeds on tandem cold reduction mills. These mills receive cold steel strip about one-tenth of an inch thick and in a series of four or five passes reduce the thickness to about one one-hundredth of an inch. The steel strip is used for automobiles, refrigerators, cans, stoves, and toys.

Silicon Controlled Rectifier

NEW semiconductor device which will replace relays and certain power industrial tubes has been developed by General Electric Co. and was announced by **H. Brainard Fancher,** general manager of the Semiconductor Products Dept., in a speech to the Cleveland Society of Security Analysts.

The silicon controlled rectifier will find wide use as a combination electric power relay switch and conversion device. Applications for the new device were listed as a replacement for power transistors in guided missile power supplies; replacement of thyratron tubes in commercial welders; use in industrial motor control circuits for

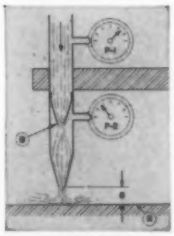


If Your Problem is to Control Winding and Unwinding Speed–
as the Diameter Changes

THIS ASKANIA FOLLOW-UP SERVO SYSTEM IS THE SOLUTION

This diagram shows the operation of an Askania Follow-Up Servo System used for controlling winding and unwinding speed—*as the diameter changes.*

In this application the distance (s) constitutes a measure of the spool diameter and the variable drive is automatically adjusted to change winding speed in accord with the changing diameter of the spool...as it winds or as it unwinds. *There is no physical contact* with the surface...thus the surface of the wire or material being wound cannot be marred or injured.



INJECTOR NOZZLE

Sensing element of the system is the unique patented Askania Injector Nozzle which provides a pressure signal to the Askania Jet Pipe Controller.

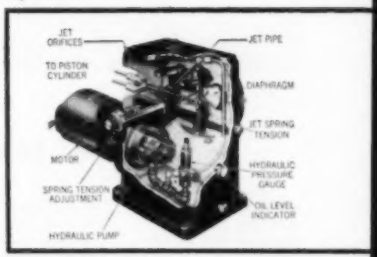
HAVE OTHER CONTROL PROBLEMS?

A host of similar industrial control problems are being solved with similar Askania Servos using Jet Pipe Controllers. Do your problems include any of these:

- Three dimensional positioning
- Maintenance of constant distance between tool and work
- Cam or pattern following
- Linear follow-up of synchro positions
- Other types of tool or material positioning

Write for Application Bulletin

For information on winding or unwinding roll speed control...or any other Askania control system...write Askania Regulator Company, 244 E. Ontario Street, Chicago, Illinois.



ASKANIA JET PIPE CONTROLLER

Askania Jet Pipe Controller translates the pressure signals from the injector nozzle into corrective action by way of the Askania double end cylinder.

ASKANIA REGULATOR COMPANY
"CONTROLS FOR INDUSTRY"
Hydraulic, Electrohydraulic and Electronic Controls—
Valve Actuators and Cylinders—General System Engineering

A SUBSIDIARY OF
GENERAL PRECISION EQUIPMENT CORPORATION

GPE

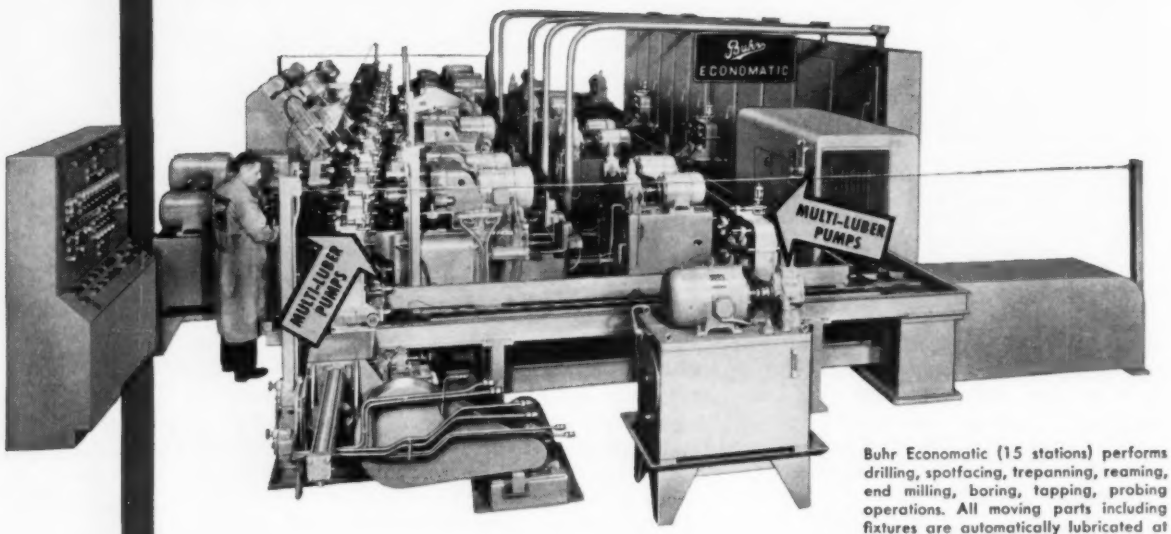
Circle 668 on Page 17

Lincoln Multi-Luber*

POWER LUBRICATION SYSTEM

...Eliminates Down-Time for Lubrication

...Cuts Maintenance and Operating Costs for this versatile special transfer machine



Buhr Economatic (15 stations) performs drilling, spotfacing, trepanning, reaming, end milling, boring, tapping, probing operations. All moving parts including fixtures are automatically lubricated at pre-determined intervals by a Lincoln Multi-Luber Centralized Power Lubrication System.

NATIONAL SALES AND SERVICE THROUGH LEADING INDUSTRIAL DISTRIBUTORS

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*Trade Name Registered

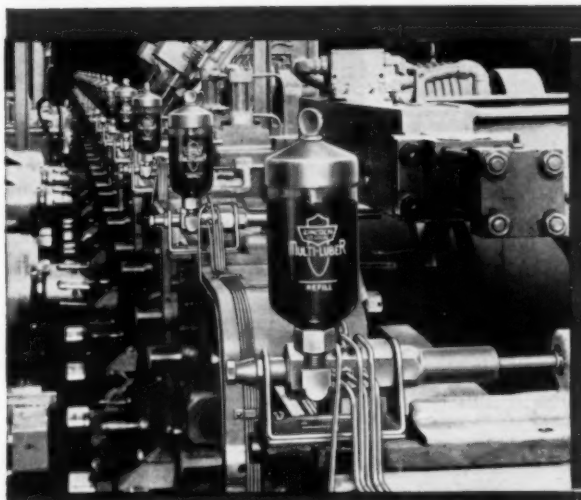
Lincoln

THE MOST TRUSTWORTHY NAME IN LUBRICATING EQUIPMENT

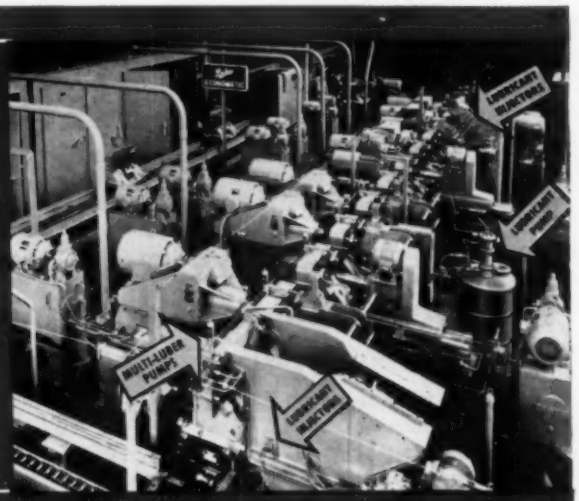
55 DIFFERENT OPERATIONS EVERY 23 SECONDS
and not one second of down-time for lubrication...

This complex, automated transfer machine demands a completely automatic lubrication system that can keep pace with its high rate of production. The Lincoln Power Lubrication System does exactly that—automatically lubricating all moving parts and fixtures three times an hour. Costly down-time for lubrication is eliminated along with excessive bearing wear and breakdowns due to inadequate or faulty lubrication. Operating costs are cut to an absolute minimum.

On existing facilities and new equipment, Lincoln Power Lubrication Systems provide you with a tested, low-cost method that improves production efficiency, lengthens service-life and reduces operating costs. Investigate now.



20 Multi-Luber Pumps serve fixtures. Pumps are actuated by using the motion of one station of machine which cycles system at each revolution of the conveyor.



Fluid Lubricant is supplied to Lubricant Injectors, serving 343 bearings, simultaneously each time system is automatically cycled (three times each hour). Injectors are supplied by a full-automatic 400-lb. drum pump.

"BUILD IN" AUTOMATIC LUBRICATION FOR TOP PERFORMANCE

SEND FOR THIS NEW FREE CATALOG

Full information and specifications on Lincoln Multi-Luber Automatic Power Drive Lubrication systems for automated lines . . . machine tools . . . production equipment . . . materials handling equipment.

MAIL COUPON TODAY!

to

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5794 Natural Bridge Avenue, St. Louis 20, Mo.

Please send me your new POWER LUBRICATION CATALOG No. 811.

Name .....

Company .....

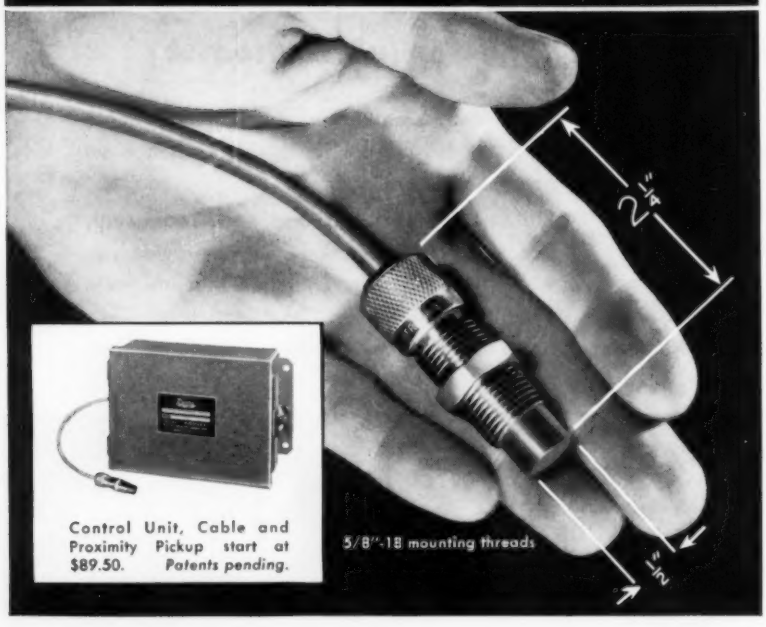
Address .....

City ..... *Zone* ..... *State* .....

LINCOLN ENGINEERING COMPANY *Division of The McNeil Machine & Engineering Co.*
5794 Natural Bridge Ave., St. Louis 20, Missouri

Electro ELECTRONIC EQUIPMENT

First in Proximity Pickups



Solve your metal control problems with this low cost proximity pickup

Compare these advantages over other proximity devices

Flexible . . . Detects both ferrous and non-ferrous metals. Sensitive to very thin metal pieces, such as aluminum foil. Does not attract or hold ferrous chips.

Compact . . . Only the small Pickup need be located in the work area. Control Unit can be located up to 50 feet or more away.

Economical . . . Low replacement cost for Pickup ($13.50).

Rugged . . . Sealed Proximity Pickups for water and oil environments.

Proven Reliability . . . Three years continuous use in automotive industry.

Qualified . . . Meets JIC requirements.

Other "plus" advantages

Versatile . . . Wide variety of Proximity Pickups available for detecting metal objects at clearances in excess of 6 inches. Suitable Hollow Coil or "pass through" type Pickups available for detecting or counting small metal parts of various sizes.

Practical . . . Associated Control Unit contains relay output for direct operation of motor controls, solenoids and electric counters.

Write or Phone for Bulletin and Name of Nearest Field Engineer

8068

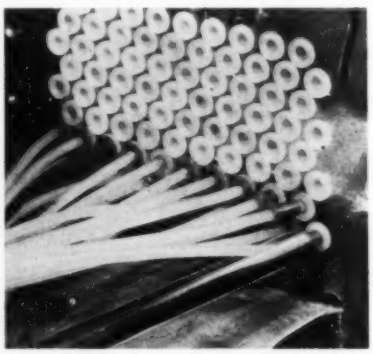
Electro ELECTRONIC EQUIPMENT

Sensing Elements for Control Counting Speed and Displacement Measurements

ELECTRO PRODUCTS LABORATORIES
4501-U Ravenswood, Chicago 40, Ill., LOngbeach 1-1707
Canada: Atlas Radio Ltd., Toronto

speed regulation; use as motor control for automatic machine tools, and replacement of relays in large industrial switching panels for controlling power distribution, chemical processing and other functions.

Fancher pointed out that the silicon controlled rectifiers are still in the laboratory development stage and probably will not be ready for initial production until the fall of 1958. Features of the new semiconductor rectifiers are their long life, very small size, and instant starting ability.



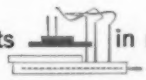
NYLON compression fittings which provide an anticorrosive, positive anchor in hydraulic and pneumatic applications using brass, copper, aluminum, steel, or nylon tubing are available from Nylon Molding Corp. Tests indicate that the new fittings withstand pressures as high as 1200 psi. Savings in time and labor result from the simplified installation required since no reaming, tapping, or flaring of a drilled hole is needed. The nylon fittings are installed by pressing the two sections together with a simple tool shown at the bottom right of the picture.

SPOTLIGHTING PEOPLE

Thomas J. Manning appointed manager of a new $4 million plant being constructed at Lincoln, Ill., by Cutler-Hammer Inc. . . . **R. L. Puette** and **B. H. Carlisle** appointed General Divisional Managers by Clark Controller Co. . . . **Carroll A. Hennessy** elected member of the board of directors of Lamson Corp. . . . **John J. Bricker** elected vice president of International Business Machines Corp. . . . **Theodore G. Vickers** named plant manager of Ross Operating Valve Co. . . . **William J. McGraw** appointed general sales manager and **Walter G. Mitchell** named general manager of product development by Thor Pow-

BETTER LUBRICATION BEGINS WITH ALEMITE **OIL-MIST**

How to cut lubricant costs up to 90% — and increase production!

Large and small plants  in many industries are making important maintenance savings while actually boosting machine output—with Alemite Oil-Mist Automatic Lubrication.

The Oil-Mist system atomizes oil into air-borne particles, carries them through tubing to all lubrication points and bathes every moving surface with a cool film of clean lubricant while machines operate. It provides constant, uniform, completely automatic lubrication to a few or to hundreds of bearings. Accurate and foolproof, Oil-Mist eliminates guesswork. No bearing can be overlooked or over-lubricated.

Three types of Oil-Mist fittings apply lubricant in the form required. Either a mist fitting or a condensing fitting or a spray fitting, is used to lubricate any lubrication point.

An Oil-Mist system can be applied to any new or installed machine. Find out in detail how it cuts costs, reduces man-hours and machine downtime, extends bearing life, and increases production.

Write Alemite, Dept. MM-28, 1850 Diversey Parkway, Chicago 14, Illinois.

Makers of these automatic centralized lubrication systems: Oil Mist · Accumatic · Accumite

1850 Diversey Parkway, Chicago 14, Illinois

ALEMITE DIVISION **STEWART-WARNER CORPORATION**

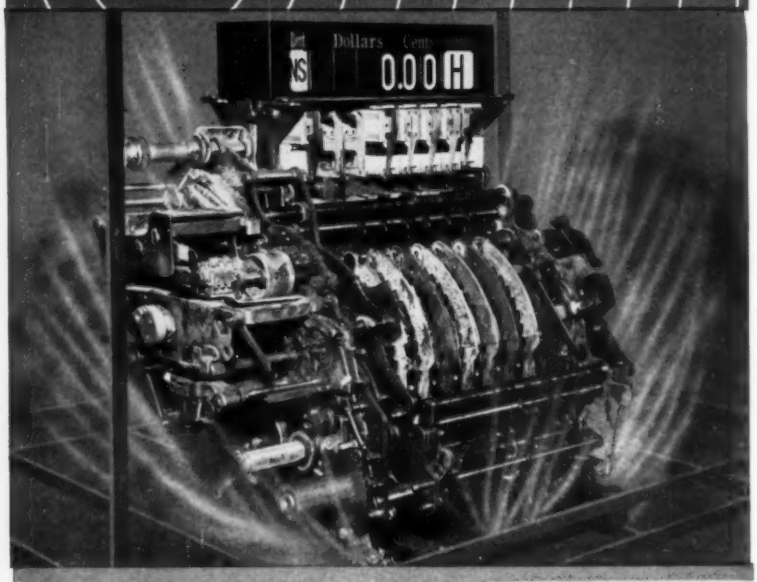
Symbol of **SW** Excellence

Circle 671 on Page 17

5,000 CASH REGISTER PARTS CLEANED IN 7½ MINUTES WITH

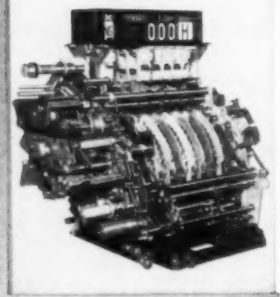
ULTRASONICS

(DETREX SONICLEAN PROCESS)



Thousands of hours...thousands of dollars saved by a modern miracle... DETREX Sonicleaning!

After years of service even NATIONAL CASH REGISTERS collect dust, oil and dirt. Now, a costly hand-cleaning method of preparing integral parts for reconditioning has been replaced by DETREX Sonicleaning. In this specially designed Ultrasonic Soniclean Degreaser sound waves literally "blast" the soil from the maze of parts. Three or four Registers can be cleaned at once in a few minutes with the Detrex Soniclean unit. After cleaning, quick inspection tells which parts need adjusting or replacing. NATIONAL CASH REGISTER technicians then make the unit ready for many years of additional service. The full range of DETREX services and facilities assures superior performance.



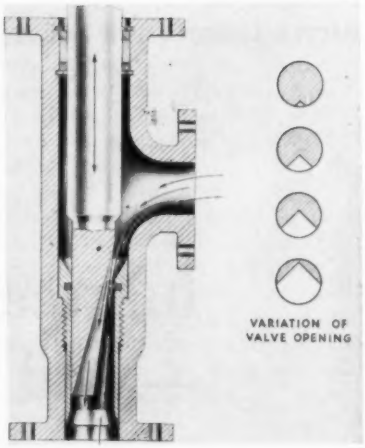
Only DETREX has Sonicleaning Installations in ALL These Applications:

Aircraft • Automotive • Household Appliances • Jewelry • Machine Tools • Electric Razors • Jet Engines • Surgical Instruments Business Machines • Electrical Equipment

Detrex, a pioneer in the Metal Cleaning and Processing Field, is now the established leader! Offering the most complete combination of chemicals, equipment, and services in the industry, Detrex can properly recommend, engineer and service any cleaning application. Write for information today!

DETREX CHEMICAL INDUSTRIES, INC.

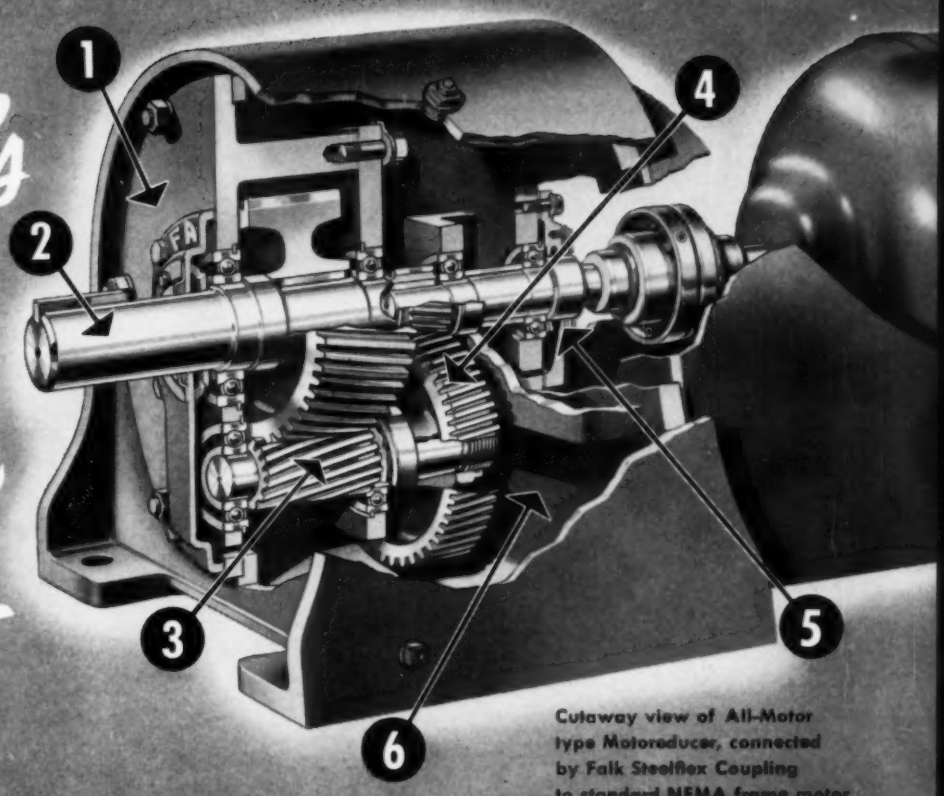
BOX 501, DETROIT 32, MICHIGAN



TAPERED orifice valve developed by General-American Valve Co. offers a different concept of flow control for liquids which might contain foreign materials. By moving a plug with a tapered slot into and out of a circular opening, the flow of a fluid or gas is controlled by the area of the tapered slot at the head of the opening. Circular sealing ring eliminates by-pass. For use in applications similar to needle valves, tapered orifice valves will give variable control, non-clogging, low turbulent flow at all settings.

er Tool Co. . . . **Zeke R. Smith** elected vice president of Potter & Brumfield Inc. . . . **Walter Fleck** appointed manager of manufacturing and **Donald Denlinger** named production superintendent for the receiving tube plant of Westinghouse Electric Corp. . . . **Carl Neisser** appointed manufacturing manager of the Systems Div. of Beckman Instruments Inc. . . . **John C. Borden** elected to board of directors of Cutler-Hammer Inc. . . . **Edwin A. Link** and **Bruce McCauley** elected to the board of directors of Shand & Jurs Co. . . . **Joseph F. Degen** appointed vice president of manufacturing for Weston Electrical Instrument Corp., a subsidiary of Daystrom Inc. . . . **John H. Moorman** named head of a new research facility for the fundamental study of the die casting process at Aluminum Co. of America . . . **Albert H. Carr** elected vice president of Communication Measurements Laboratory Inc. . . . **Eugene P. Cunningham** appointed vice president of Clearing Machine Corp., a division of U. S. Industries Inc. . . . **James I. Ashley** appointed sales engineer for the Press Div. of E. W. Bliss Co. . . . **Robert A. Slater** appoint-

Here's the inside story—



Cutaway view of All-Motor type Motoreducer, connected by Falk Steelflex Coupling to standard NEMA frame motor

WHY Falk Motoreducers give better service—have longer life

Here is the "inside story" behind the all-steel All-Motor type FALK Motoreducer's universal reputation as a gear drive unmatched in quality, efficiency, dependability, ease of maintenance and long life. These "In-built" factors are—

1 **ALL-STEEL HOUSINGS.** Rugged, strong, rigid...all parts are manufactured from heavy steel plate, formed and welded in the Falk Weld Shop.

2 **LARGE OVERHUNG LOAD CAPACITY.** Large shafts, oversize bearings...rigid mountings with wide bearing spans to handle maximum applied loads.

3 **PRECISION GEARING.** Heat-treated alloy steel gearing, precision cut and shaved after heat treatment to eliminate distortion. Quiet, crown-shaved pinions.

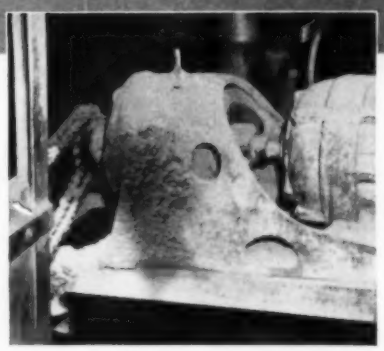
4 **EXTRA-CAPACITY GEARING.** Special extra-capacity gear-tooth form with larger contact area gives greater strength, higher load-carrying capacity.

5 **SEALED HOUSINGS.** Splashproof, dustproof, oil-tight construction. Dual closures and one-way vents keep oil in, dust and moisture out.

6 **POSITIVE LUBRICATION.** Large sump capacity...oiltight construction assures clean lubricant...revolving elements lubricated by direct dip.

When you buy or specify the All-Motor type FALK Motoreducer, you get all these—plus the tremendous advantage of full interchangeability of motors. Switch motors as desired—use any make, style or type of standard foot-mounted motor within the unit's AGMA rating—with a minimum of difficulty or "down time."

Available in sizes up to 75 hp—*with or without motor*—from convenient factory, field or distributor stocks, from coast to coast. **Write for Bulletin 3100.**



60,000 HOURS WITHOUT A FAILURE!

Sixty thousand hours is a lot of hours—but the FALK Motoreducer in the unretouched photo above has served that long without failure or need of repair.

This 3 hp unit is one of over 60 FALK Motoreducers in daily service in an Eastern plant of a large milling company, whose president says, in part:

"One of the main advantages of FALK Motoreducers is their adaptability to any motor. Reducers and motors can be easily interchanged....Our service records confirm the wisdom of our choice of FALK equipment as our standard."

FALK ...a good name in industry

THE FALK CORPORATION, MILWAUKEE, WISCONSIN

MANUFACTURERS OF

- Motoreducers
- Speed Reducers
- Flexible Couplings
- Shaft Mounted Drives
- High Speed Drives
- Special Gear Drives
- Single Helical Gears
- Herringbone Gears
- Marine Drives
- Steel Castings
- Weldments
- Contract Machining

Circle 673 on Page 17

Ceiling's the limit...

with Hinde & Dauch boxes. How do your boxes stack up? Sturdy H & D boxes have stacking strength built in. They stand straight. For top to bottom product protection, better see H & D.

HINDE & DAUCH

Division of West Virginia Pulp and Paper Company

Authority on Packaging • Sandusky, Ohio
15 Factories • 42 Sales Offices

ed manager of manufacturing engineering in the Metallurgical Products Dept. of General Electric Co. . . . **Sylvan E. Franklin** appointed manager of the industrial reactor group of Control, a division of Magnetics Inc. . . . **Philip DiFalco** appointed chief engineer of Le Maire Machine Tool Co. . . . **John H. Hunt** named director of manufacturing and **C. J. Jordan** named production planning manager for Stavid Engineering Inc. . . . **Walter W. Finke,** president of the Datamatic Div., elected vice president of Minneapolis - Honeywell Regulator Co.

SPOTLIGHTING PRODUCTS

Tube bending clip for holding a 90 degree bend in plastic tubing in such applications as instrumentation, hydraulic, lubrication, air or other fluid lines is available from Polymer Corp. of Penn. . . . *Laminated metal foil flexible tubing* having a zipper type fastener to provide a shielded casing for multiconductor wiring is available from Zippertubing Co. . . . *Paste type solder alloys* for use in newly developed automatic dispensers capable of depositing a metered amount of material at a rate of 8000 dots per hour are available from Fusion Engineering Co. . . . *Bobbinless precision wire fixed resistors* produced by a new winding process whereby the units are embedded in epoxy resin without the bobbins or winding forms are offered by Chicago Telephone Supply Corp. . . . *Variable resistors* mounted side-by-side in 2-unit and 3-unit assemblies and equipped with plug-in mounting brackets are available from Electronic Components Div., Stackpole Carbon Co. . . . *Electronic tube* which will simultaneously display radar or TV images with identifying letters, numerals, and symbols superimposed has been developed by the Stromberg-Carlson Div. of General Dynamics Corp. . . . *New process for etching printed circuits* using an aqueous solution of ammonium persulfate as the etchant has been developed by Becco Chemical Div. of Food Machinery & Chemical Corp. . . . *New series of heat curing supported composite film adhesives* for honeycomb sandwich construction which provide

Circle 674 on Page 17

You learn a lot in a hundred years... especially in the hundred just passed

—the greatest century of technical progress the world has ever seen. Born as it was, on the brink of the era, the growing Bliss Company was in a position to make a number of contributions to pressed metal-working... the first inclinable press, for example, and the famous rolling key clutch, the toggle press principle, pneumatic clutches, these are some of the more important ones.

Proud? Of course we are—of these contributions and of the men who made them possible. For we've learned in our past century that: Any company, no matter what its size, is basically people... that a customer isn't a purchase order, but someone to whom we are responsible both now and in the future. This is part of what we mean when we say, "Bliss is more than a name... it's a guarantee."

BLISS
SINCE 1857

E. W. BLISS COMPANY · Canton, Ohio

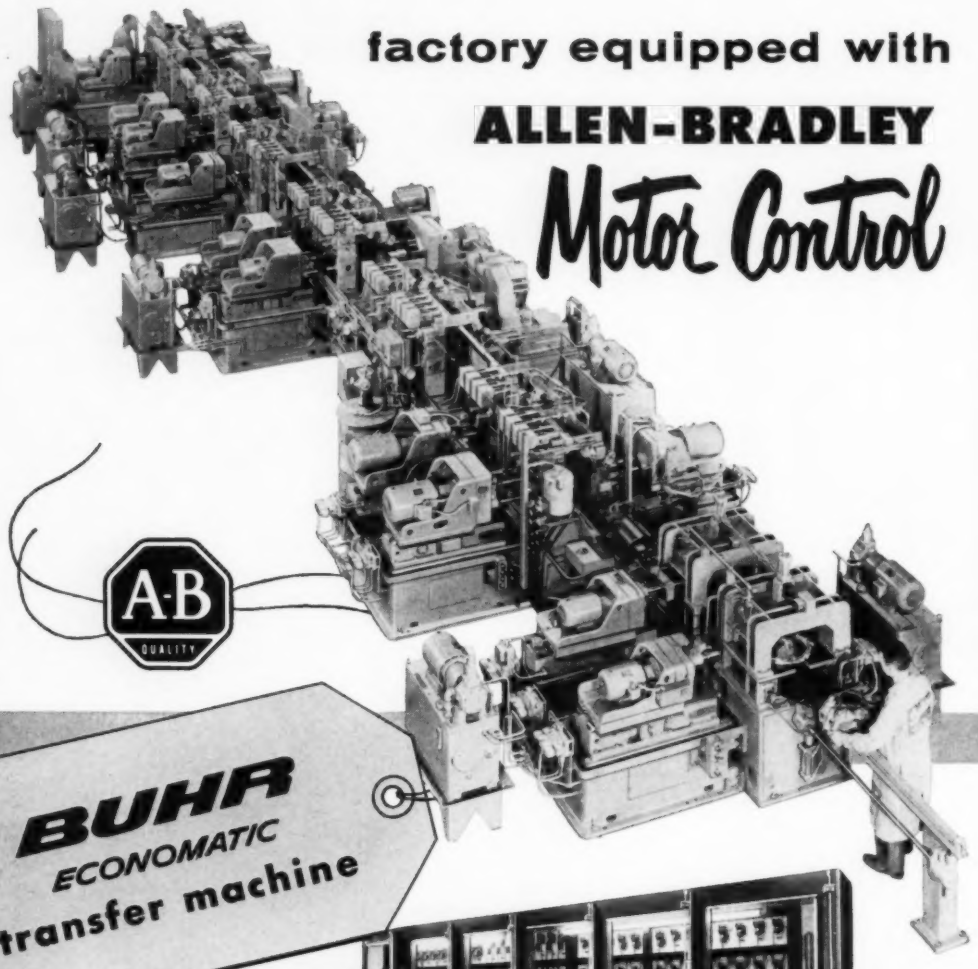
100 years of making metal work for mankind

PRESSES • ROLLING MILLS • ROLLS • DIE SETS • CAN MACHINERY • CONTRACT MFG.

Circle 675 on Page 17

factory equipped with

ALLEN-BRADLEY Motor Control



BUHR ECONOMATIC transfer machine

The motor control panel used with this Buhr transfer machine is completely equipped with standard Allen-Bradley control units listed in the A-B Handy Catalog.

As operations required of huge automation machine assemblies multiply, so does the importance of the motor control "reliability." And for that reason Allen-Bradley—the motor control that assures *millions* of trouble free operations—is usually preferred above all others.

The simple solenoid design around which all Allen-Bradley motor starters and relays are built has only ONE moving part. There are no pivots and bearings to corrode and stick . . . assuring fast, consistent, contactor operation. And the double break, silver alloy contacts—standard through the entire Allen-Bradley line—are always in perfect operating condition. Specify Allen-Bradley control! In so doing, you can't possibly make a mistake.

Write for your copy of the new Allen-Bradley Handy Catalog—a 132-page guide to *quality* motor control.

ALLEN-BRADLEY

MOTOR CONTROL

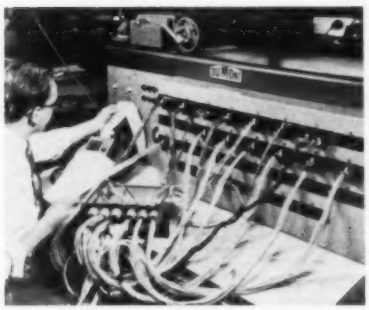
QUALITY

Allen-Bradley Co., 1339 S. First St., Milwaukee 4, Wis.
In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

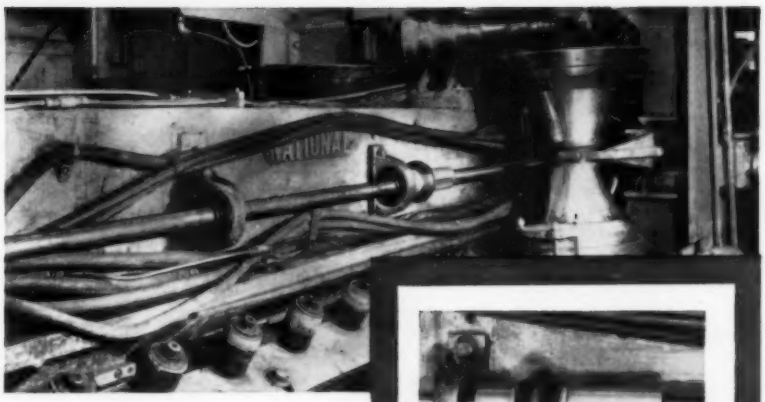
a high combination of peel and beam shear strengths has been developed by Minnesota Mining & Manufacturing Co.

SPOTLIGHTING PLANTS

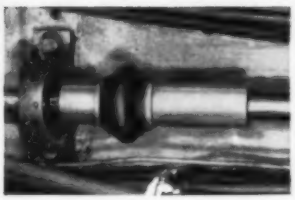
Clark Controller Co. has established a new Automation Div. which will handle engineered control systems and standardized controls for applications requiring integrated control systems such as mill drives, processing lines, conveyor systems, and machine tools. . . . **Gardner-Denver Co.** has announced abandonment of proposed plans for merger with Dresser Industries Inc. . . . **General Controls Co.** has established a new Electronics Controls Div. to produce analog servos for position and velocity control, transistor and magnetic amplifier packages. . . . **Miniature Precision Bearings Inc.** has broken ground for a new $350,000 ball bearing plant in Lebanon, N. H. . . . **Wilbur B. Driver Co.** has recently opened a new alloy wire mill in Santa Maria, Calif., which will produce fine resistance wire and stainless steel wire for West Coast customers. . . . **Magnetic Research Corp.** has announced formation of a new Stablvolt Div. which will manufacture power supplies and related equipment for use in communications, military, and industrial applications. . . . **Con-**



MULTIPLE function automatic tester has been designed by Allen B. Du Mont Laboratories Inc. to speed production testing of junction boxes at its Equipment Manufacturing Div. The tester will check for continuity, correct wire connections to terminals, condition of wire insulation, and resistance. Having a capacity of 900 input points, the automatic device can make 30 individual wiring tests per minute. A tape reader programs the various test procedures from punched tape, and a serial entry printer automatically records the test step number and test result.



AUTOMATION creates a drive-line problem..



solved with *an APEX covered* universal joint

Automation is nothing new at the Rheem Manufacturing Company plant at Sparrows Point. Here, 55-gallon steel drums are formed, fabricated and finished without a hand touching the product in the process.

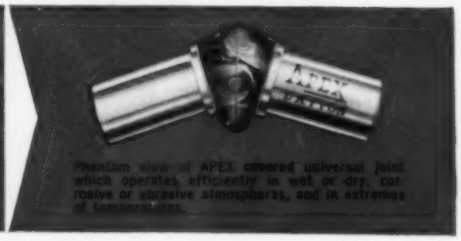
On the fully automatic line, perfect register is essential. To achieve this, an automatic device, incorporating an Apex universal joint, positions each drum perfectly as it engages the rollers.

Paint and varnish create atmospheric conditions which would be harmful to ordinary universal joints, but which have no adverse effect on this Apex covered universal joint. The flexible cover, available only on Apex universal joints, not only protects the joint but also insures clean, sustained lubrication.

This is one reason why, on so many automated operations, Apex covered universal joints are specified for drive-line applications. And it's the reason why you should ask Apex about industrial universal joints for *your* drive-line applications. Why not write today, on your company letterhead please, for our new Catalog 28?

1933 *A Quarter Century of Service to Industry* **1958**

THE APEX MACHINE & TOOL CO.
1936 South Patterson Blvd.
DAYTON 2, OHIO



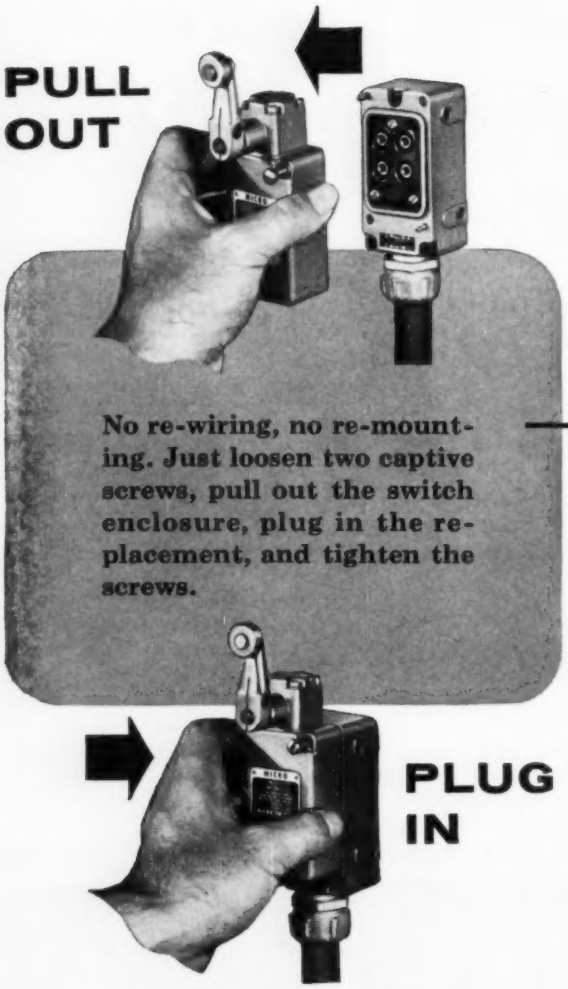
Phantom view of APEX covered universal joint which operates efficiently in wet or dry, corrosive or abrasive atmospheres, and in extremes of temperatures.

Circle 677 on Page 17

MICRO SWITCH Precision

These outstanding NEW precision switches enable design engineers to save space, time, maintenance and installation costs

High quality with reliability has made MICRO SWITCH the leading manufacturer of precision switches with the largest line of switches from which to select. MICRO SWITCH plants and development laboratories are equipped with scientific tools for painstaking precision, quality control and testing techniques. Field Engineering offices blanket the country. There is always a MICRO SWITCH man near you—ready to cooperate on switching problems.



No re-wiring, no re-mounting. Just loosen two captive screws, pull out the switch enclosure, plug in the replacement, and tighten the screws.

(Send for Bulletin No. 20)

How you can cut "down time" with this "Plug-in Limit" switch

Here's a real timesaver for users of precision limit switches—a revolutionary new precision limit switch that can be replaced IN SECONDS. The MICRO SWITCH "Plug-in Limit" answers a prime requirement for designers of devices for use on high speed automatic production lines. It offers all the features of rugged construction and precise, long-life operation of the industry-proved MICRO SWITCH "LS" Series. Yet the switch enclosure, including all mechanical and electrical parts, is plugged into the terminal block as easily as a radio tube. Dowel pins assure precise positioning.

Switches have uses unlimited

How to get more pushbutton switches on a panel

MICRO SWITCH Series 100 PB Lighted Pushbutton Switches provide an unusually neat, good looking panel. Their compact mounting allows more switches per panel.

Important features include:

Three types of illuminated signal—

(1) one-color buttons, (2) two colors (lighted singly or in combination) and (3) choice of either of two colors—neither of which is visible when button is unlighted.

Large, easily engraved buttons—

Buttons are large enough to allow two lines of clearly legible engraving.

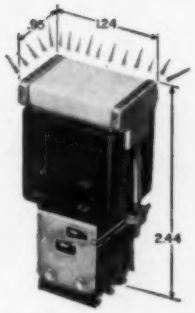
Wide choice of circuitry—

Because separate terminals are provided for each lamp and for each element of the contact structure, these switches permit intermixing of voltages, a-c or d-c current and even combinations of opposing polarities.

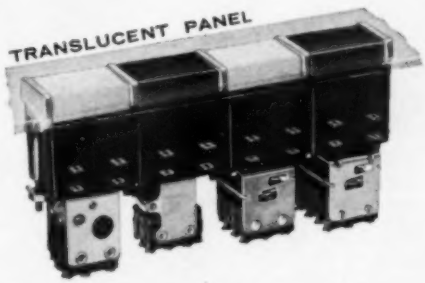
Matching lamp assemblies available—

Matching indicating lamp assemblies are available with the same button and lamp combinations and the same means of mounting as the complete 100 PB switch assembly.

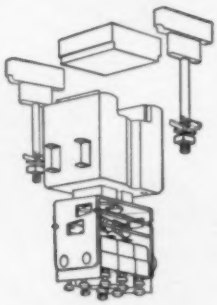
(Send for Data Sheet 143)



Typical switch module on a 3-circuit design.

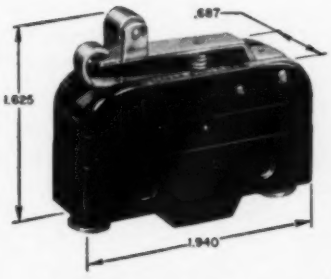


A typical compact assembly of switches in panel slots. Indicates choice of button color and number of circuits.



Exploded view showing switch assembly, button and mounting means.

A roller-lever switch with the stability of pin-plunger switch



A new design in roller-lever actuators is this MICRO SWITCH Type W.

This small, compact roller-lever basic switch is ideal for use of such control mechanisms as radar units, precision machine tools or other devices where precise actuation with little variance in operating points is required.

This Type W switch incorporates a new design in roller lever actuators which gives it an operating stability similar to a pin-plunger switch—low pre-travel, narrow differential travel and close repeatability but also permits exceptionally high overtravel.

The roller is located on top of a double lever. As the roller is depressed, both levers move downward until the switch is actuated. The upper level then proceeds on downward, providing the high overtravel. The limited overtravel given to the snap spring and a low break gives this switch a long, trouble-free mechanical life.

(Send for Data Sheet 127)

MICRO SWITCH

A DIVISION OF MINNEAPOLIS-HONEYWELL REGULATOR COMPANY

In Canada, Leaside, Toronto 17, Ontario • FREEPORT, ILLINOIS

First in Precision Switching

Circle 678 on Page 17

the shortest route to MORE PROFIT
. . . produce MORE in 1958!

If you can reduce costs while producing more, the job is twice as easy. This is where PEECO can help.

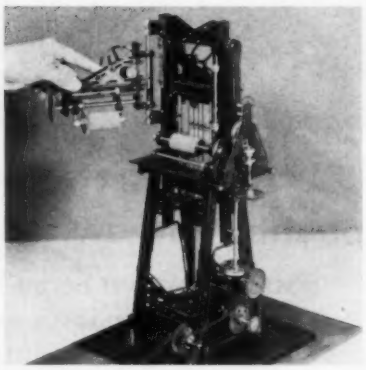
In every case illustrated above, as well as in hundreds of other examples, PEECO successfully helps production men reduce their costs by producing more—automatically.

If your equipment, machinery, production or assembly line is *not* now using parts feeders the chances are your costs are too high. Let a PEECO Sales Engineer give you the facts. He'll gladly help you without obligation. Write for literature and name of representative near you.

THE WORLD'S LARGEST EXCLUSIVE MANUFACTURER OF VIBRATORY PARTS FEEDERS

Peeco DIVISION...AUTOMATION DEVICES, INC.

32nd & BRANDES STS., ERIE, PA. • PHONE 4-6329
IN CANADA 96 KIPLING AVE. NORTH, TORONTO 18, ONT.



MACHINE construction kit, designed to enable engineers to make precision working models of various types of machines, is available from FAC Div. of Overseas Commodex Corp. The working model shown of a log saw was constructed from precision-machined mechanical components furnished in the kit. Models made with the kit can be used for testing new ideas and mechanisms in design work.

---

trol Data Corp. has purchased Cedar Engineering Inc. to provide additional production facilities for the manufacture of data processing devices. . . . **Tipptronics Inc.** has transferred to Cleveland the manufacture of electromechanical devices for the control and monitoring of industrial equipment. . . . **Stephens-Adamson Mfg. Co.** has started production in a new plant at Clarksdale, Miss., which will fabricate component parts for conveying systems. . . . **Ramo-Wooldridge Corp.** and Thompson Products Inc. have announced the formation of a new subsidiary corporation, Thompson - Ramo - Wooldridge Products Inc., which will market equipment for industrial process control. . . . **LeMaire Machine Tool Co.** is the new name for LeMaire Tool & Manufacturing Co. . . . **Analytic Systems Co.**, a division of Research Instrument Corp., has completed arrangements to manufacture and sell infrared and ultraviolet process stream analyzers formerly manufactured by Applied Physics Corp.

MEETINGS AND EVENTS

Feb. 4-6—

Society of the Plastics Industry Inc. 13th Annual Technical and Management Conference of the Reinforced Plastics Div. to be held at

Illustrated—Logansquare Cylinder Meets J.I.C. Standards

Look to Logan

the ultimate in air cylinder design

FREE SEND FOR THE "LOGAN CALCULATOR"
A gift to you from Logansport Machine Company upon request.

MEMBER: Natl. Mach. Tool Builders' Assn.; Natl. Fluid Power Assn.

LOGANSPORT MACHINE CO., INC.
848 CENTER AVENUE, LOGANSPORT, INDIANA

PLEASE SEND COPY OF CATALOG:

- ☐ 100-1 AIR CYLINDERS
- ☐ 100-2 MILL-TYPE AIR CYLS.
- ☐ 100-3 AIR-DRAULIC CYLS.
- ☐ 100-4 AIR VALVES
- ☐ 100-5 LOGANSQUARE CYLINDERS
- ☐ 100-5-1 ULTRAMATION CYLINDERS
- ☐ 300-2 PRESSES
- ☐ FACTS OF LIFE
- ☐ 200-1 HYD. POWER UNITS
- ☐ 200-2 ROTOCAST HYD. CYLINDERS
- ☐ 200-3 750 SERIES HYD. CYLINDERS
- ☐ 200-4 and 200-7 HYD. VALVES
- ☐ 200-6 SUPER-MATIC CYLS.
- ☐ 300-1 CHUCKS
- ☐ ABC BOOKLET
- ☐ CIRCUIT RIDER

TO:

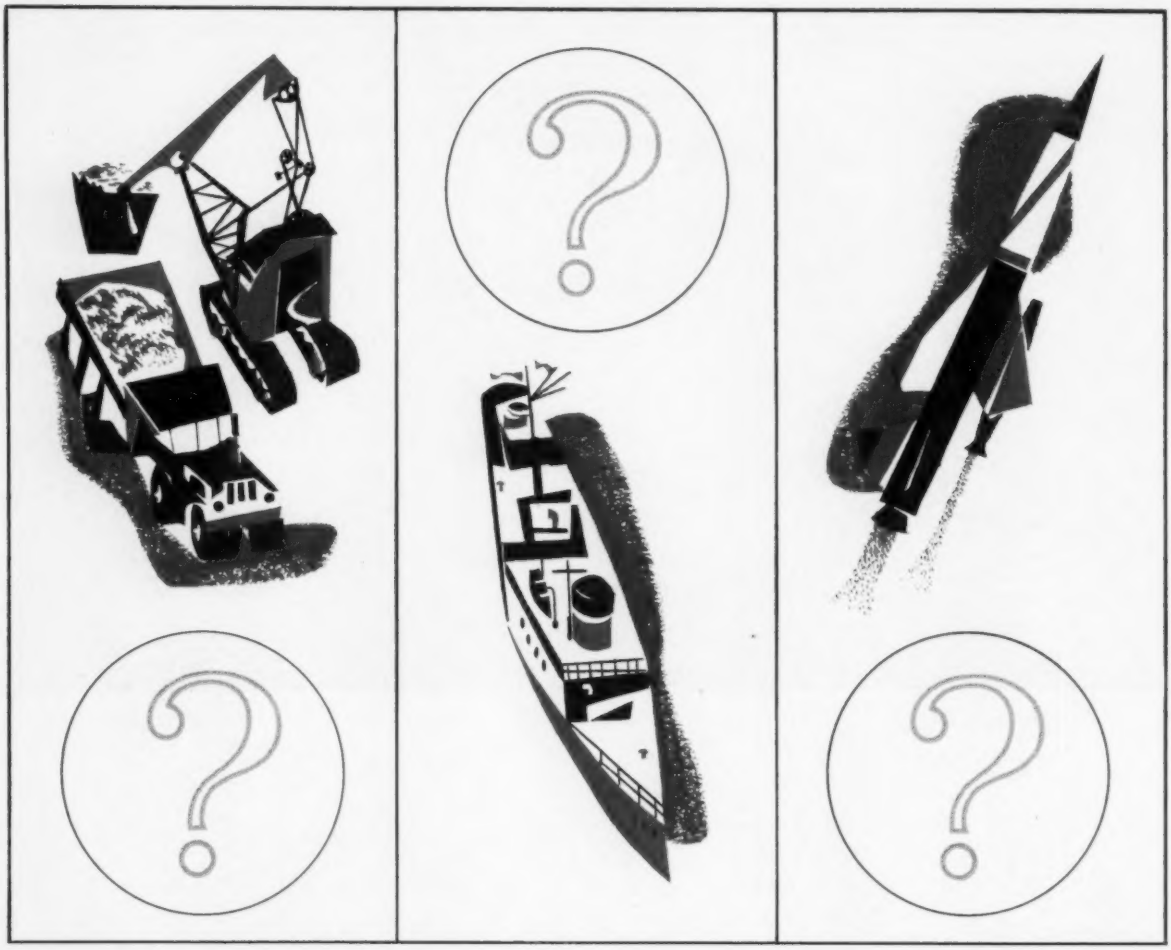
NAME_____ TITLE_____

COMPANY _____

ADDRESS _____

Circle 680 on Page 17

are you looking for switches controlled by speed



AC-Milwaukee now produces a speed sensing switch so sensitive that it operates, and continues to operate, within ½ of 1% of turbine speeds ranging from 500 to 4600 rpm. If you need to control from one to four engine functions in relation to turbine speeds, AC has the answer. This speed sensing switch has proved itself in thousands of operational hours on military jet aircraft . . . controlling ignition systems and afterburners in flight.

The AC Speed Sensing Control weighs about four pounds and is compact enough to be mounted almost anywhere. It holds calibration even when subjected to high engine vibration . . . can operate without servicing for periods up to those recommended for jet engine overhaul.

For help in solving any problem related to automatic control of electrical switching operations, call AC-Milwaukee.

If you are an engineer with a mechanical, electronic or electrical background, and would like to work with AC's Milwaukee group, write Mr. Cecil Sundeen, Supervisor of Technical Employment, Dept. K, 1925 E. Kenilworth, Milwaukee 1, Wisconsin.

AC SPARK PLUG ⚛ THE ELECTRONICS DIVISION OF GENERAL MOTORS

Inertial Guidance Systems • Afterburner Fuel Controls • Bombing Navigational Computers • Emergency Fuel Controls
Gun-Bomb-Rocket Sights • Gyro-Accelerometers • Gyroscopes • Speed Sensitive Switches • Speed Sensors • Torquemeters

KING-SIZE, automatically operated slide rule was designed by engineers at Minneapolis-Honeywell Regulator Co. as a unique gift to factory manager Jim Locke. An electric motor maneuvers the 3-foot long slide rule through calculations and aids it in performing mathematical steps with push-button ease. This king-size leg-pull will probably be used to solve only major problems.

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the Edgewater Beach Hotel, Chicago. Additional information is available from SPI headquarters, 250 Park Ave., New York 17, N. Y.

Feb. 7-8—

American Society for Quality Control. Second national conference of the Administrative Applications division to be held at Carter Hotel, Cleveland. Additional information is available from William C. Lynam, B. F. Goodrich Chemical Co., 3135 Euclid Ave., Cleveland 15, Ohio.

Feb. 13-15—

National Society of Professional Engineers. Spring Meeting to be held at Michigan State University, East Lansing, Mich. Additional information is available from NSPE headquarters, 2029 K St. N.W., Washington 6, D.C.

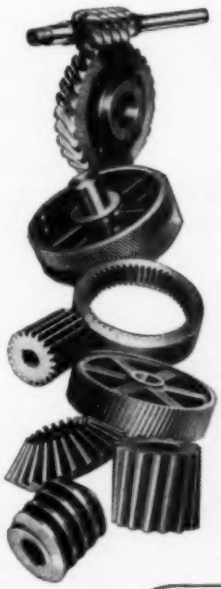
March 3-6—

American Society of Mechanical Engineers. Gas Turbine Power Div. conference and exhibit to be held at the Shoreham Hotel, Washington, D.C. Additional information is available from Barry Freer, 1300 Connecticut Ave. N.W., Washington 6, D.C.

March 10-11—

American Machine Tool Distributors Association. 34th Spring Meeting to be held at The Roosevelt,

This H&S Gear Catalog



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Circle 682 on Page 17

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FLOW TRANSMITTERS...

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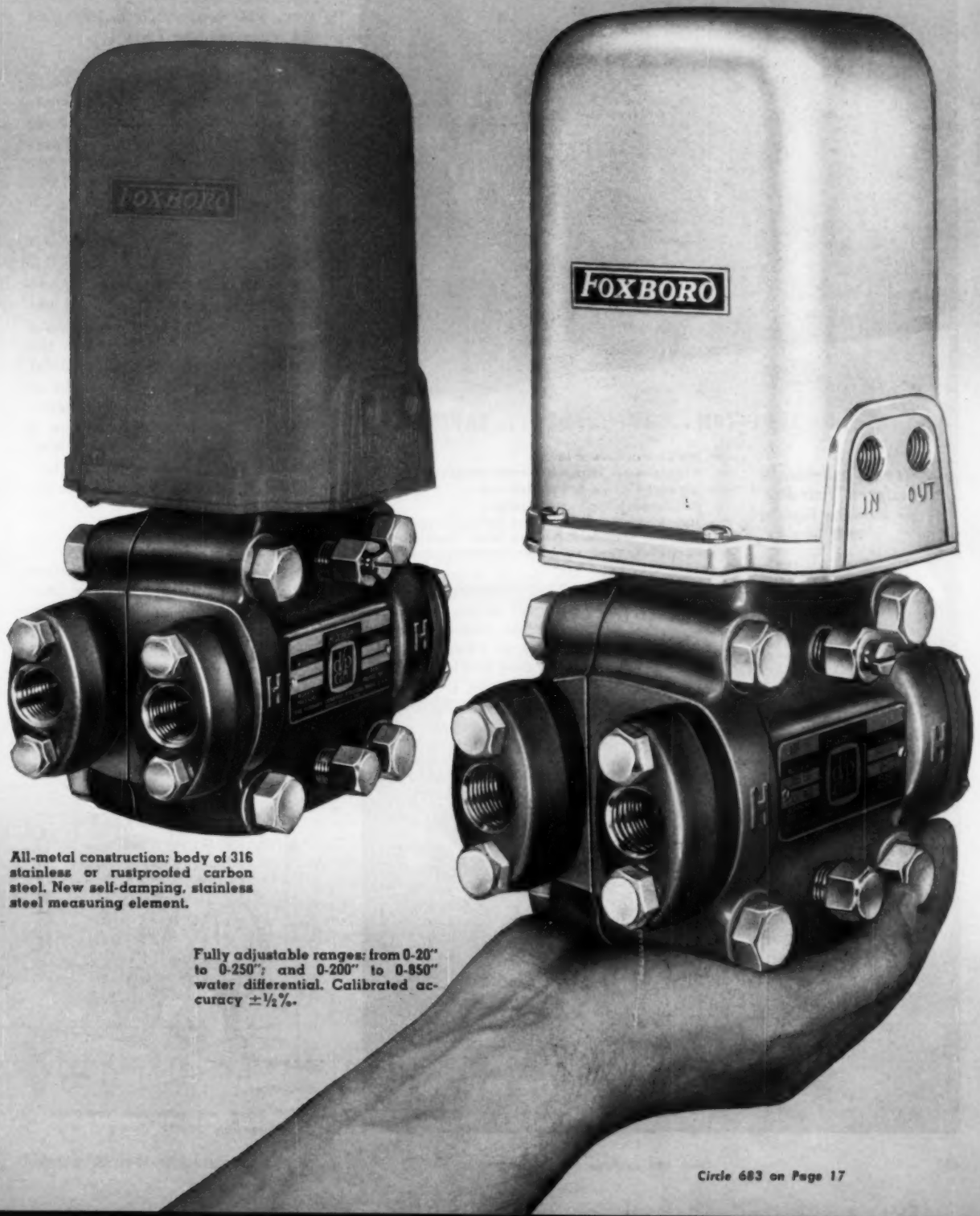

All-metal construction: body of 316 stainless or rustproofed carbon steel. New self-damping, stainless steel measuring element.

Fully adjustable ranges: from 0-20" to 0-250"; and 0-200" to 0-850" water differential. Calibrated accuracy ±½%.

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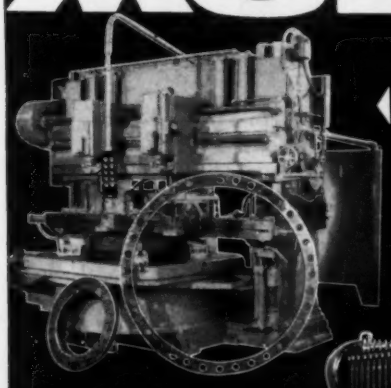
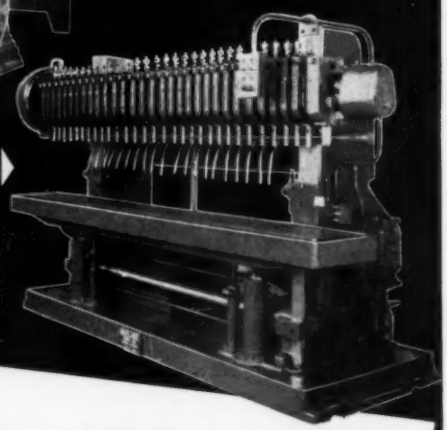
MOLINE



HD68 drills bolt circles from 12" to 100" diameter. Each of the two spindles has capacity for 2½" drill in steel. Operating cycle is fully automatic.



HD13 straight line-type drilling machine with capacity for thirty ¾" drills in steel. Used for work on heavy castings, round and rectangular steel tubes, structural shapes, plates and grader blade drilling or countersinking.

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PRODUCTION . . . EFFICIENCY . . . SAVINGS

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- Multi-Spindle Boring
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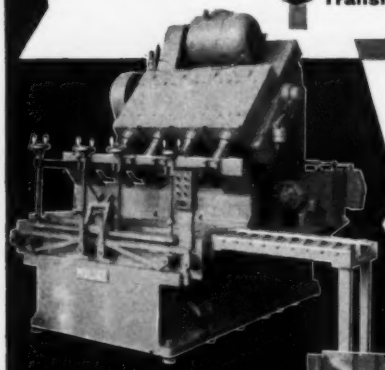
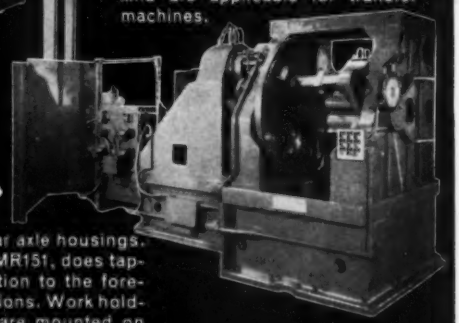


13CB hydraulic feed cylinder boring machine. V-8 engine blocks are rough and finish bored for wet-type cylinder sleeves. Units of this kind are applicable for transfer machines.



MR152 performs drilling, reaming, spot facing and chamfering operations on tractor rear axle housings. A companion machine, MR151, does tapping in addition to the foregoing operations. Work holding fixtures are mounted on power driven trunnion.

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109

New Orleans, La. Additional information may be obtained from Al Bourgeois, Convention Manager, The Roosevelt, New Orleans, La.

March 11-14—

Pressed Metal Institute. Spring Technical Meeting to be held at the Sheraton-Cadillac Hotel, Detroit. Additional information is available from PMI headquarters, 3673 Lee Rd., Cleveland 20, Ohio.

March 17-18—

Steel Founders' Society of America. 56th Annual Meeting to be held at the Drake Hotel, Chicago. Additional information may be obtained from George K. Dreher, 606 Terminal Tower, Cleveland 13, Ohio.

March 17-21—

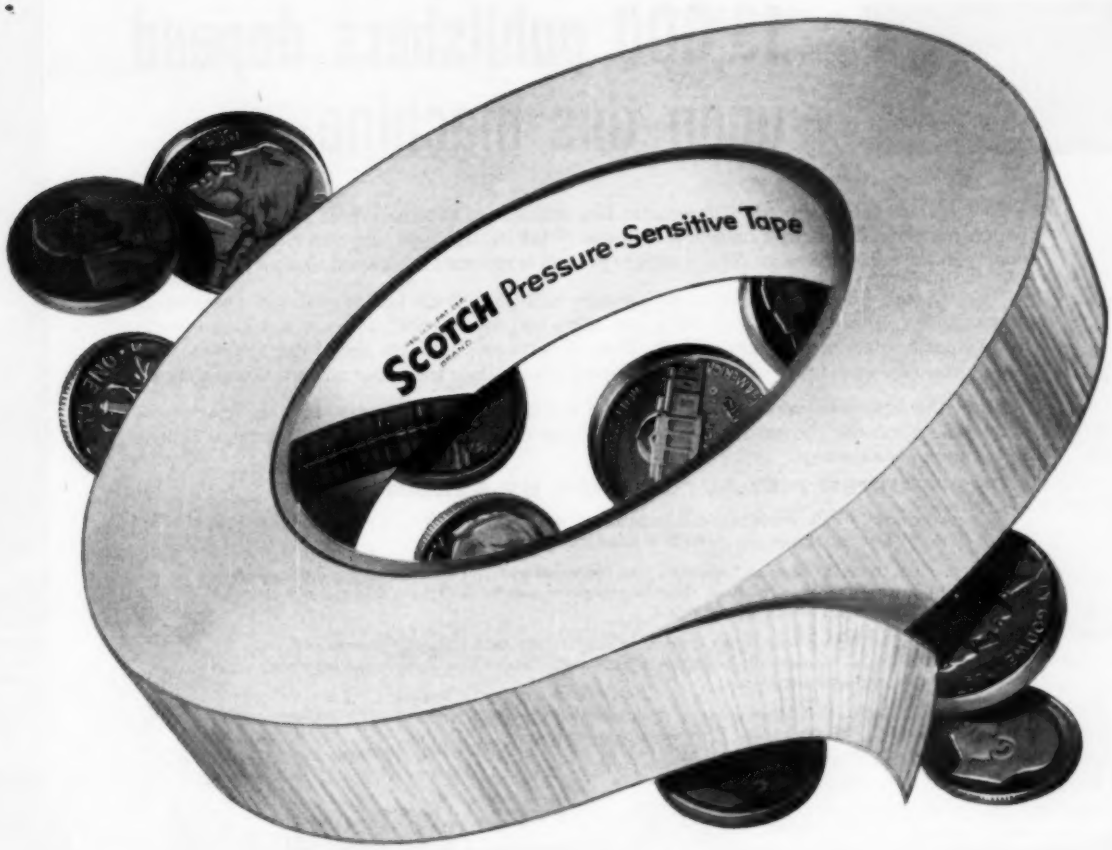
Fourth Nuclear Engineering and Science Conference. Sponsored and conducted by over 30 engineering and scientific societies under the co-ordination of Engineers Joint Council. Conference to be held at the International Amphitheatre, Chicago. Additional information is available from John A. Dever, Minneapolis-Honeywell Regulator Co., 707 W. Grange St., Philadelphia 20, Pa.

March 25-28—

Packaging Machinery Manufacturers Institute. Packaging Machinery & Materials Exposition of 1958 to be held at Convention Hall, Atlantic City. Additional information is available from the PMMI headquarters, Suite 759, 1 Gateway Center, Pittsburgh 22, Pa.

AUTOMATION

"I know we advertise complete automation, Harry, but . . ."



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3M COMPANY

THE IMPACT OF *Automation* ON TODAY'S BUSINESS

13,000 publishers depend upon this machine

The modern printing press is an outstanding example of automation. It picks up a sheet of paper, positions it, places a measured amount of ink on the type, impresses the type on the paper, and restacks the sheet. The complete process is repeated a hundred times a minute.

Over 13,000 different American newspapers and periodicals are turned out on printing presses today. These publications bring you news and information, without which you would find yourself doing business in the dark. They directly employ more than 350,000 people, and make possible a wide range of investment opportunities, from the paper mill to the news stand.

All of this would be impossible without the automatic printing press—another example of how automation has proved to be not only a wise capital investment, but a general benefit to the nation's economy.

HORSEPOWER FOR AUTOMATION BY RELIANCE

This rotary press, which prints sheets as large as 48" x 73", is powered by a 20 hp. Reliance V*S Drive. The press will print as many as 6000 of these sheets in an hour.

The pressman can select the exact speed for best operation with the wide range of operating speeds available from the V*S Drive. Because there are no gears, speeds can be pre-selected and changed during operation without stopping the press.

The Reliance Drive provides a controlled rate of acceleration, protecting the press from damage by fast starts. The drive automatically programs a gradual deceleration for stopping. A separate circuit gives a fast sure stop for emergencies.

If you would like further information on Reliance V*S Drives for any type of machinery, write for Bulletin A-1555, "Widening The Horizons of Automation." D-1558

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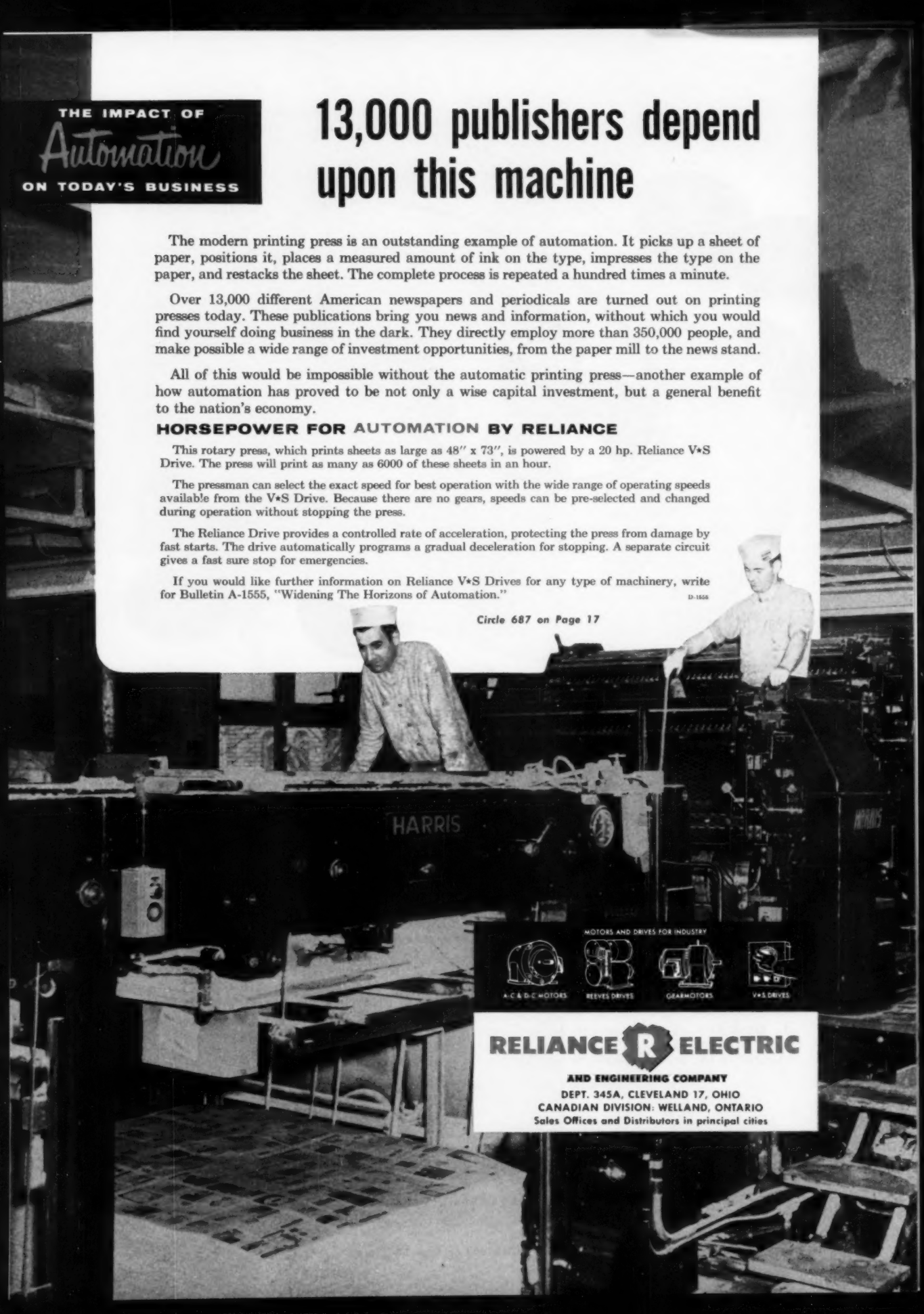

RELIANCE R ELECTRIC

AND ENGINEERING COMPANY

DEPT. 345A, CLEVELAND 17, OHIO

CANADIAN DIVISION: WELLAND, ONTARIO

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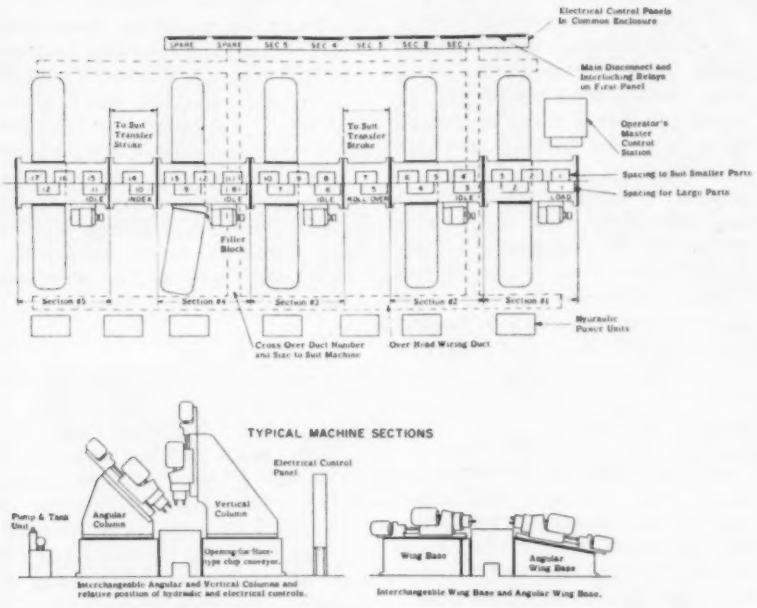
By JAMES C. KEEBLER
Managing Editor


Electrical Control Panels in Common Enclosure
Main Disconnect and Interlocking Relays on First Panel
Operator's Master Control Station
To Suit Transfer Stroke
To Suit Transfer Stroke
Spacing to Suit Smaller Parts
Spacing for Large Parts
Filler Block
Section #5
Section #4
Section #3
Section #2
Section #1
Hydraulic Power Units
Cross Over Duct Number and Size to Suit Machine
Over Head Wiring Duct
TYPICAL MACHINE SECTIONS
Electrical Control Panel
Pump & Tank Unit
Angular Column
Vertical Column
Opening for Slant-type chip conveyor
Interchangeable Angular and Vertical Columns and relative position of hydraulic and electrical controls.
Wing Base
Angular Wing Base
Interchangeable Wing Base and Angular Wing Base.

Ford Motor Co. has established general specifications for interchangeable components of in-line transfer machines.

Building Block Automation

STANDARDIZATION of dimensions to permit interchangeability is one of the cornerstones of the American industrial scene. Lamp bulbs made by one manufacturer are interchangeable with those made by another. Yet in the early days of the lamp industry this was not so, and until such time as standards were agreed upon, many different lamp base designs were in production and use. Similar questions of standardization face automaters today.

Standardized Stagnation?

This idea of standardizing on dimensions has mixed blessings. The economics of the situation might be said to fall within the scope of the Law of Compensating Disadvantages.

Once a standard is set, those who own nonconforming equipment soon find that it is obsolete and in order to get mating replacements must pay the premium price that goes with buying "specials." The alternative is to pay the price of converting to the standardized version.

After a period of time when everyone owns the standardized version some rightly conclude that the long-range adherence to arbitrary standards has stifled technological progress. On the other side of the ledger, they have benefited from the flexibility of interchangeability and have enjoyed the savings that accompany purchase of mass-produced items from competitive sources of supply.

For commercial products such as lamp bulbs the case is usually clear cut in favor of standard dimensions. But for production equipment, which must be specially adapted for the product being made, factors affecting standardization are more complex.

Pioneering Effort

It is significant that those who pioneered in the use of the word *automation*, to describe their efforts to link production operations into automatic lines, are also pioneering in establishing standards for dimensions of the building blocks that make up only one type of automated production equipment—transfer machines. Under the leadership of Harder and Davis the Ford Manufacturing Engineering Office, directed by J. F. Randall, has been working on the program and a lot of water is over the dam already.

This effort goes beyond the bounds of individual company standards and seeks industry participation from other users and machine tool builders.

Basic Blocks

Since large transfer machines cannot be built on a monolithic base (if for no other reason than shipment from builder to user) it is common practice to make bases in sections and fasten them together. Wings to mount tool slides fasten to the sides of the base sections. Vertical columns fasten to the wings, and support tool slides that approach from above.

The basic configuration of many of these units made by most manufacturers is very much the same. In some cases the similarity is so striking that the representative of one builder might easily mistake the identity of a competitor's product for that of his own when viewed at a glance. This situation exists for both in-line transfer and rotary index type machines.

Ike and Mike

Though they may look alike there is usually no interchangeability between units made by competitors. The question at hand is: "Why not?" Ford is advocating that mounting dimensions and some other exterior configuration sizes of these building block components be standardized in the machine tool industry such that a drill slide unit from one transfer machine vendor might be replaced by a drill slide unit made by another.

This proposal is not unlike the currently existing ASA standard for spindle noses on lathes. A

chuck made by any manufacturer following the standard will fit a lathe made by any manufacturer following the standard for the same size spindle nose. Similar standards for milling machine and drill spindle tapers exist and are widely used.

There is more behind the program however than the open choice of sources. The problems of flexibility at model change time are very much a part of the picture. If interchangeable building blocks were in use, leftover drill units from a remade manifold machine might be installed on a remade bearing cap machine which got its extra base wings from a remade cylinder head machine.

The use of standardized building blocks would thereby not only save dollars in retooling but also save time in getting equipment built.

Everybody Wins

On the surface it might appear that such a standardization program would be a good way for the machine tool builders to slit their collective throat. It can be reasoned that if the reason for adopting such a program is to cut equipment costs the net result would be to cut equipment sales and the builders would lose business. This reasoning may be too shallow, for other factors influence the relationship.

If builders do not wish to band together and formulate standards there is nothing to prevent the user from adopting company standards and achieving a large part of this savings anyhow.

It can be reasoned that if such standards existed, builders could make units "for stock" in slack times with a more reasonable assurance that they would eventually be sold if the market for such units included a more widespread segment of industry. If standardized units were made on a higher production basis and price savings were effected, there is a great possibility that more customers would sign up for transfer-type production lines. Expanded markets mean more business.

Plug-In Production

Many user companies have already standardized to a large degree. Delco Remy's rectangular transfer machine bases for assembly machines represent a standard building block approach. Rochester Products has design standards of bases, wings and tool slides as well as other transfer machine components. These designs are not available to other companies nor are they available to these user companies as standards of the trade.

Trends toward plug-in control units for ease of maintenance, and toward self-cycling production units that plug into a central control system all point in the direction of increased use of the building block approach.

Whether the acceptance of building blocks will be of such magnitude to warrant industry's standardizing on mounting dimensions is a point of contention. There is still the payoff cost-calculation to consider and still many places where a single-purpose machine tool without speed or feed adjustment or any of the other ramifications that make for flexibility, will pay off best. Yet it may be that acceptance will follow standardization with sufficient enthusiasm as to warrant the program.

How Far To Go

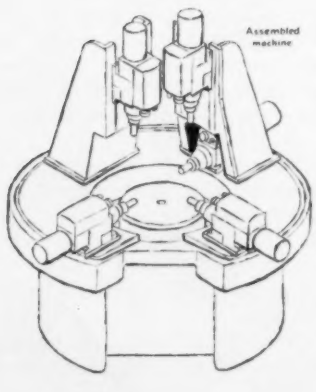
One thing is apparent in the present situation. No one has to use any of the existing standards, and no one would be compelled to use any of the proposed standards. The real effectiveness of standards seems to lie in the availability of workable standards for use by all those who wish to do so, and the dissemination of the details of those standards so that they become more widely used and therefore more effective.

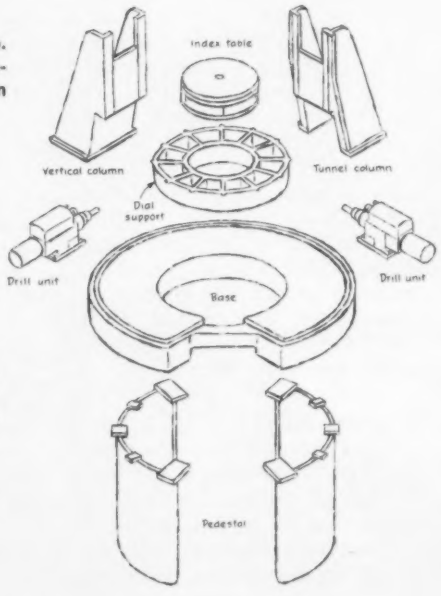
Joint Industry Conferences have done this type of standards work for electrical, pneumatic, hydraulic and press room standards used by the automakers. Such a conference on building blocks might have a tough row to hoe in reaching agreement on what dimensions to set as the standards, but would most likely be in agreement that some standards are in order.

How far this effort should go is the big question. There are many ramifications that this little ball of yarn has not even mentioned. Included in these are: 1. Depreciation policies and allowed practices. 2. Provisions to update standards apace with improved design ideas. 3. Government's roles: missile program—mobilization potential—stockpiling. 4. Vested interest views.

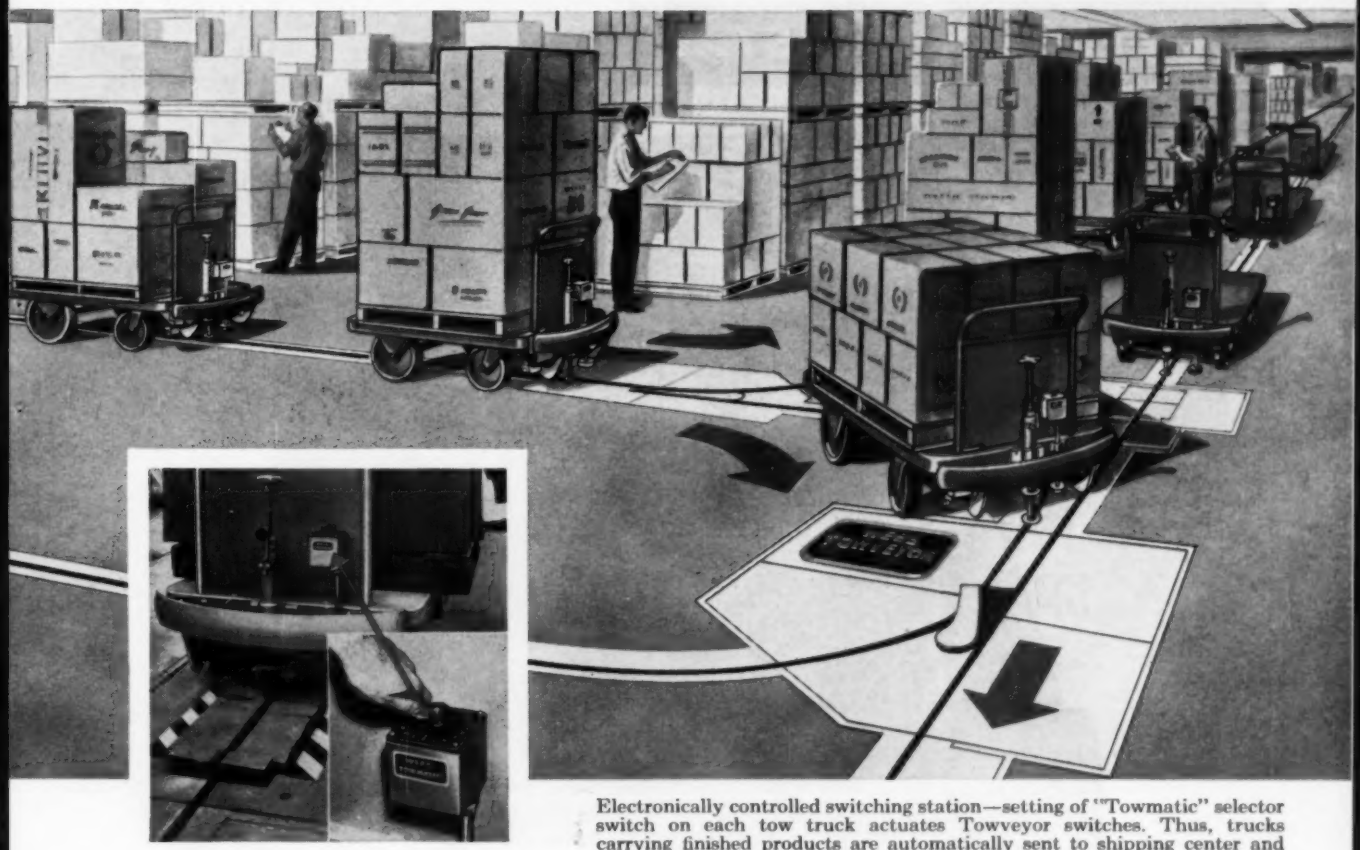
Since the question of standardizing dimensions of transfer machines is a prime concern to a segment of AUTOMATION's readers we solicit comments on the pros and cons of this issue in the hope that we may play a part in the interchange of ideas so necessary to helping such a program along in the right direction.

Hartford Special Machinery Co. manufactures standardized components that are assembled to form rotary indexing machine tools.





FIRST Electronically Controlled Towveyor . . .



Electronically controlled switching station—setting of "Towmatic" selector switch on each tow truck actuates Towveyor switches. Thus, trucks carrying finished products are automatically sent to shipping center and all other trucks are diverted to Towveyor at right.

Slashes Handling Costs . . .
Prevents Traffic Snarls . . . Speeds Production

Johnson & Johnson, in designing their "Plant of Tomorrow", gave major consideration to efficient materials handling. Required was a handling system providing: lower handling costs—smoother traffic flow—increased production—reduced manual handling—integration of materials movement in and between three buildings—automatic delivery of a variety of materials to many locations.

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In fact, all materials handling, in the two manufacturing buildings and shipping, centers around this 3624 foot Towveyor. To provide electronic control for movement of materials, each tow truck is equipped with a 19-station Towmatic selector switch—each station representing a different location in the plant. Thus, by simply flipping Towmatic switch to desired station and lowering tow pin into Towveyor slot, the tow truck is started on its way—electronics take over and materials automatically travel to their destinations.

Two other Towveyors located in shipping center wind through order-picking areas to provide at-hand-convenience for personnel filling customer orders. Towtrucks carrying filled orders are placed on these Towveyors for unescorted travel to loading dock. By automatically performing the multiple materials handling operations required in manufacturing, warehousing and shipping, Towveyors at J & J reduce manual handling—lower operating costs—speed production.

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For a detailed description of the Johnson & Johnson Towveyor system and its many benefits, write for 12-page Bulletin 28.

Webb in-floor Towveyor and overhead Tow-Conveyor systems are completely described and illustrated in Catalog 157—write for your free copy.

Circle 687 on Page 17

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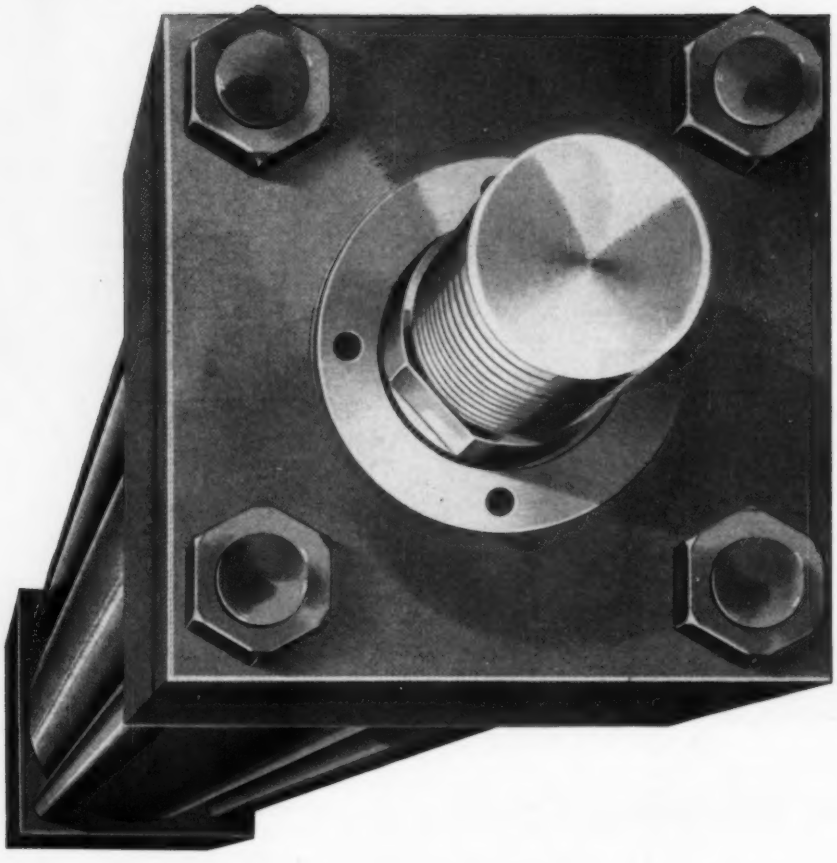

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Anker-Holth Division, for 18 years designers and manufacturers of quality air and hydraulic power cylinders, now offers a standard line of all steel, high pressure square head tie rod cylinders. Important new operating features and design achievements assure positive controlled power for a wide range of industrial applications.

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Conservatively rated at 2000 P.S.I. working pressure and 3000 P.S.I. non-shock pressure every cylinder is proof tested at 4500 P.S.I. All mountings are available, standard bores from 1½ to 8 inches. Standardized mountings provide complete interchangeability with most makes of square head cylinders. The Anker-Holth "□" line meets all J.I.C. specifications.

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Spotlight on Costs

Few businessmen will deny that 1957 was a banner year in many ways. Gross national product reached an all-time high and capital equipment investment in terms of plant and machinery topped all records at 37.1 billions. Installation of automated facilities likewise reached a new peak in numbers and diversification.

Yet there is a certain air of pessimism in some quarters that appears unwarranted. A slowdown in buying of hard goods has not been reflected in public spending. The last quarter has shown spending to be still on the rise. Forecasts for 1958 indicate it will closely parallel 1957, and possibly increase.

Reluctance to continue buying some hard goods carries with it an indication that prices may be considered a bit high. Price reductions could very well spur a market upsurge since demand and need have not significantly changed. Reduction in production costs can play a key role in this regard and study of the production equipment market confirms industry's thinking along these lines.

Use of automation to increase output has given way to a new trend—use of automated production facilities to reduce unit costs. Here is the key purpose and outstanding value in automation. Creating an organic system of the processing steps necessary to manufacture a product offers outstanding economic results but carries with it the apparent burden of being "specially engineered."

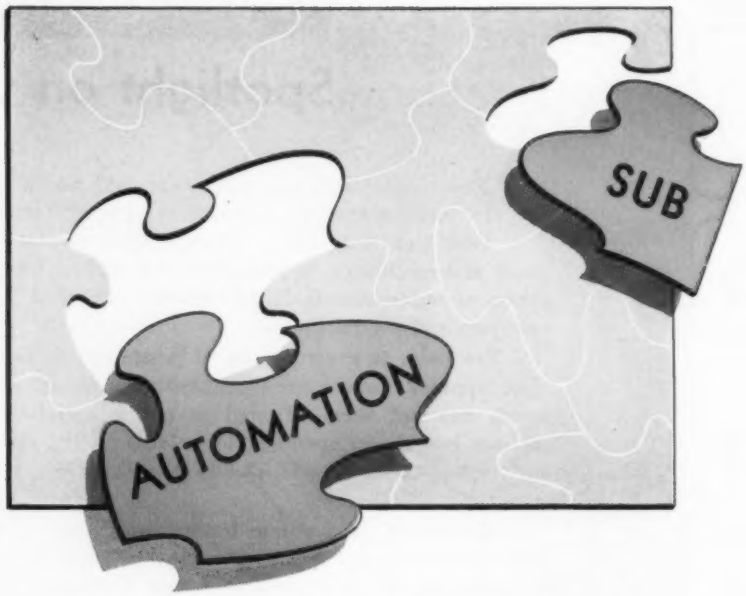
Thus, the builder of "standards" in the area of production equipment finds business off to a dismaying degree. Those builders who have sensed the need and trend of the times, the experts in the field of automated equipment design, on the contrary find business still excellent or increasing.

More and more the path of production processing leads in the direction of automation. Lowest possible unit costs at any quantity level call for equipment "tailored" to do the job.

We are gradually moving into a new era where the spotlight will be on manufacturing and processing engineering. Cost takes on a new significance and modern equipment builders must be ready to serve the need of the times.

EDITOR

AUTOMATION



NOW IS THE TIME—THESE ARE THE FACTORS—

GUIDEPOSTS TO AUTOMATION PLANNING

By L. H. WORTHMAN and J. H. LEMELSON
Work Simplification Supvr. Chief Methods Engineer
U. S. Metals Refining Co.
Carteret, N. J.

PROGRESS in technology promises many things—including the certainty that in our society industrial management will become more complicated. Besides current operating decisions, the manager must interpret the future in terms of the past and present and, with imagination, plan for and work toward obtaining that position most beneficial to his particular company.

In production, the technical future is not a complete enigma since the manager of today has been given a concept which has been shown to be valid in the past, which is expanding tremendously in the present, and which offers a logical answer to anticipated requirements of the future. This concept is automation.

As a philosophy, automation encompasses the entire productive effort. It suggests that within the bounds imposed by the economics of a particular situation at any given time, there is an

To establish the connection, if any, between automation and supplemental unemployment benefits, the authors made a study of industry. Their conclusions: The connection is tenuous at best but basic principles have been identified which are important to a company concerned with preparing for the future.

optimum design for a product and its method of manufacture.

As a practical concept, automation is capable of widespread application only when it is realized that the modern industrial manager is not simply operating within some capricious economic climate subject to unidentifiable random perturbations. Modern management has considerable influence over the limiting variable of economics. This influence can be exerted by investigating new things with an open mind, planning details with determination, and obtaining a superior degree of cooperative work from all personnel within an organization.

In manufacturing organizations, it is co-operation that results in improved communications and understanding, and in the inspired activity necessary to achieve the common goal of all business enterprises—economic success. This means that in considering automation there is a need to examine many aspects of management responsibility that might at first glance appear to be entirely unconnected with a technology concerned with more automatic production.

A Case In Point

Originally thought of as two unrelated factors, automation and supplemental unemployment benefits must be considered together in some instances today when reaching management decisions. In short, the effect of technological advances on employment has become a controversial matter in labor-management negotiations. This raises an important question for plants considering automation: "Is automation in any way related to supplemental unemployment benefits?"

Perhaps the first point to be considered is that both automation and supplemental unemployment benefits (SUB) are established facts and are no longer simple issues. Actually, neither automation nor the philosophy of supplemental unemployment payments is new. The historical precedents for automation have been well documented, and investigation reveals that numerous companies, in some cases entire industries, have had plans in effect which include provisions similar to those now identified as SUB.

However, various reports, surveys and published articles by labor, management, government, educators, and other responsible groups show that during the past ten years automation and SUB have developed into major influences in the economic life of our nation. It can be inferred that the growth of these two factors will increase with the passage of time. This interpretation means that alert management has a need to adequately prepare for the advent of either or both of these phenomena.

Anticipate the Future

For the purposes of general discussion the population of this country can be divided into three age groups: Those under working age; those over working age; and those of working age. The amount of goods produced, and consequently the living standard of all, are dependent on the third group—the nation's labor force. With a steadily increasing birthrate, increasing number of young people attending college, greater financial independence of people over 65 taking them out of the labor market, the decrease in immigration, and other factors, the ratio of those persons of working age to the total population of the country is decreasing. The only means by which our present standard of living can be maintained is through increased productivity; any improvement in our living standard requires even greater productivity increases. Increased mechanization and automation are the tools available to provide this increased productivity. Related to this classic extrapolation of present data is the observation that consumer income must of necessity rise with the larger gross national product that is envisioned. Most of this rise is expected to come from increased wages and farm income. From these viewpoints it would appear that the future is indeed secure and in the long run we should see an unprecedented prosperity for all, based upon what we know as full

YEAR	POPULATION (millions)	NUMBER EMPLOYED (millions)	GROSS NATIONAL PRODUCT (billions)	PER CAPITA SHARE GNP	VALUE OF GOODS AND SERVICES PER WORKER
1930	123.1	45.5	$165	$1340	$3620
1940	132.1	47.5	208	1575	4370
1950	151.7	60.0	322	2050	5370
1955	165.0	63.2	391	2370	6190
1965	190.0	74.0	560	2960	7500

Fig. 1—Data is taken from information furnished by Departments of Commerce and Labor, and Council of Economic Advisors. Economic projections for 1965 are based primarily on 2.3 per cent yearly increase in per capita share of GNP, 2.8 per cent yearly increase in output per worker, and an assumed 6 per cent reduction in annual hours of work.

CONSIDER THESE POINTS IN PLANNING FOR PROGRESS

☑ Investigate product design and validity of factors which are believed to influence design.

1. Anticipate future design modifications and changes that will result because of such modification.

2. Tolerances should be close enough so that parts do not jam the equipment but not so tight that inspection and reject costs are out of proportion to total costs.

3. Products should be originally designed or redesigned for most efficient machine handling and transfer.

4. Wherever possible, design so that standard, inexpensive components can be purchased and used instead of making or having special parts made.

☑ What types of people will be needed to operate, maintain, and repair future production equipment?

1. Begin psychological testing of present employees to determine which are suited to upgrading.

2. Consider all potential employees in the light of possible upgrading in the near future.

☑ General objectives and/or policy for an overall plan must be conceived and articulated by higher management. The decision as to whether to set up a separate automation engineering department or give the present design engineering, production engineering, or manufacturing engineering department responsibility for obtaining the required equipment is dependent upon many factors and will vary from one firm to another. However, once the choice has been made, responsibility and authority should be clearly outlined, asserted, and supported.

1. Investigation should be made to determine precisely what is required of any equipment being considered, particularly in relation to the general plan.

2. Pertinent periodicals should be scrutinized and catalogued.

3. Equipment and machinery suppliers should be contacted where such assistance is warranted.

4. The cost to design and build in-plant should be estimated.

5. Estimate parts replacement factors and how much of a spare parts inventory will be required before deciding whether to make, have built, or buy and alter.

6. If the decision is made to have the equipment built, or designed and built by an outside manufacturer, make certain that the builder retains his responsibility through the debugging period until the machinery is in production.

☑ The maintenance system might require radical changes. Both maintenance workers and supervisors must be inculcated with the principle that their function has changed from equipment to production maintenance.

1. Preventive maintenance is essential. Schedule this work to be done during equipment idle periods.

2. Fixed maintenance crews, with as many men as are needed, should be assigned to specific production areas.

3. Familiarize the maintenance people with the new equipment during the debugging period.

4. Establish and maintain rigid schedules for equipment inspection, tool changes, and lubrication.

5. Promote co-operation and close communication between maintenance and production supervision.

6. Establish records, based on daily reports by maintenance men, to accurately determine maintenance costs, equipment repair costs, what types of troubles most frequently occur, and if spare part stocks are correct.

☑ Industrial engineering functions will be affected. The time to improve an automatic installation is during the design phase.

1. Old jobs should be re-evaluated, and new job evaluation classification established in keeping with the true nature of work involved.

2. Plant layout activity should increase with a shift from product to process-controlled layouts.

3. Time study engineers should be trained in the use of work sampling and predetermined time standard techniques.

☑ To maintain level, year-round production and consumption, better business planning will be required.

1. Institute consumer surveys.

2. Increase and improve advertising and marketing techniques.

3. Try using joint study groups to co-ordinate production, marketing, engineering, and other business functions.

☑ The personnel department will have to expand its training facilities and will need to arrange for schools for employee training.

1. Training in hydraulic and pneumatic circuits, mechanics and electronics, and electrical troubleshooting are musts for maintenance men.

2. Supervisors and foremen must be trained to analyze faults and perform emergency repairs.

3. Production personnel must be trained to operate the equipment.

☑ Accounting procedures must be changed to reflect the new setup. The changed ratio of direct to indirect labor, the increase in maintenance costs, the upgrading of production employees, the cost to the company of funding and administering such things as a wage guarantee plan, and the use of a high process overhead cost common to several products, must all be considered.

1. Investigate possibility of using data processing equipment.

☑ The details of each supplemental unemployment benefit plan will be determined through collective bargaining, but there are certain protective provisions that every management must insist upon.

1. Government defense work should receive separate consideration as the risks of layoff in this type of work are inherently different than those in most companies' regular operations, and are usually beyond an individual company's control.

2. The company should not be required to pay benefits for layoffs resulting from labor disputes, acts of God, enemy action, or sabotage.

3. The company's sole liability should be its contributions to the benefit fund.

4. A limitation, or maximum fund amount, should be established and no contributions to the fund be made by the company above this maximum.

5. It should be anticipated that once a benefit fund is established, principles relating to its augmentation and use will be subject to negotiation.

☑ Before any supplemental unemployment benefit plan can be instituted, it must be ascertained whether or not, under the present state unemployment compensation laws, workers receiving wage benefits would be eligible for state unemployment compensation.

☑ Before installing automation, is your contract in shape?

1. Try to eliminate any clauses which, due to their ambiguity, an arbitrator might interpret as restricting the applications of automated equipment.

2. With the introduction of automation, the number of production workers and direct labor will decrease. Make sure provision has been made in the contract for measuring indirect labor.

☑ Management controls are a part of any well run company. With the introduction of automation and such factors as supplemental unemployment benefits, they become a necessity for business survival. The type of product, whether parts are manufactured or purchased, the physical layout of the plant, the nature of the business, the way in which the organizational activities are divided, and other factors will influence controls in specific firms. The objective of controls is to anticipate problems and difficulties and thereby to eliminate their occurrence. To do this effectively, it is necessary to collect, analyze, and interpret facts, with the first emphasis placed upon accuracy of collection. It is obvious that no amount of analysis and interpretation can result in proper conclusions and recommendations if the data collected are inaccurate.

1. Collection and analysis of data should begin as soon as possible so that trends can be observed, reporting omissions discovered, and weaknesses found and corrected.

2. Data should be accumulated and filed in such a manner that they are accessible when needed.

3. Data collection procedures should be as simple as possible.

4. At least two people should be responsible for the accuracy of permanent records, preferably the person reporting the data and that person's supervisor. It is advisable to have both these people sign or initial the record.

5. Data should be collected on:
   a. Material usage.
   b. Spare parts usage.
   c. Units produced and time expended in their production.
   d. Sales volume.
   e. Equipment maintenance.
   f. Costs of purchased items.
   g. Price trends.
   h. Length of time from placing order to delivery of items and materials by various vendors.
   i. Quality of incoming material from various sources.
   j. Quality of items produced.
   k. Other special data which will be useful in the routine work of the various parts of the organization.

6. The data should be collected and analyzed at frequent, predetermined intervals, and conclusions and recommendations should be reported to the parties concerned as soon as possible so that any necessary action can be based upon most recent occurrences. It is in this area that data processing equipment is most useful.

FOLLOW-UP CHECK LIST

The importance of a planning program should be impressed upon every member of the organization. Only when the procedures have become "a way of life" in the company can the necessary follow-up and follow-through be effective. These follow-up points are important:

1. Is excessive production time being lost due to parts jamming equipment?

2. Are tolerance requirements resulting in excessively high component costs?

3. Have employee training and upgrading produced the desired results? If not, why not?

4. Is the automated equipment doing the job it was originally required to do? Is it doing it satisfactorily?

5. Are the most recent improvements and innovations in the field being investigated for possible use?

6. If the vendor who supplied the present equipment was not completely satisfactory, are investigations proceeding to find a more suitable one for future work?

7. Are equipment breakdowns too frequent? If so, why? Is it because equipment inspection and maintenance times are scheduled too far apart? Is it because maintenance men are not properly trained? Is it because operators were not sufficiently trained and are abusing the equipment? Is it due to improper initial equipment design? What is being done to correct the situation?

8. Are reports and records accurate? Are they being used to keep spare parts, work-in-process, and component parts inventories at most economic levels? Are causes of most frequent troubles being investigated to discover how they can be eliminated?

9. Is the full market potential being exploited?

10. Is the present balance between sales and production at the point desired by management?

11. Are costing and budgeting realistic?

12. Is the customer satisfied with present quality? If the market gets tight, will he still be satisfied?

employment.

When this line of reasoning is subjected to a sharper scrutiny it appears that there are at least two major observations that must be made: 1. Automation doesn't just happen—it can be obtained only by the exercise of a superior imagination and the co-ordination of increasingly complex disciplines. 2. Individual workers are more concerned about the "short run" than they are about the "long run."

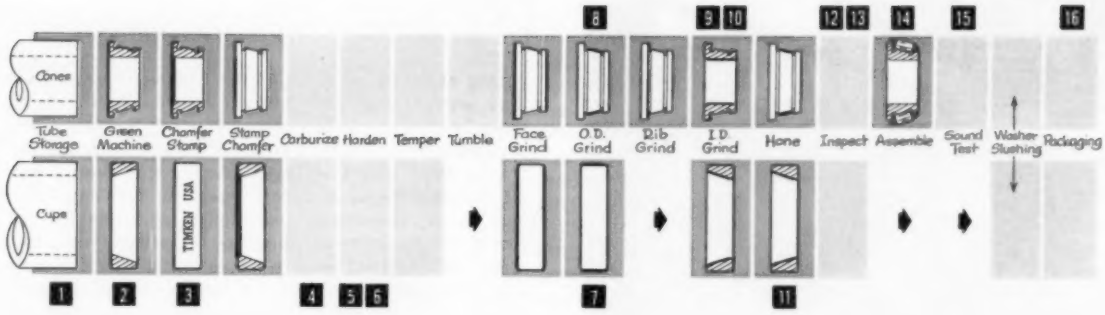
In the short run the natural mobility of the labor force results in a number of job changes which far exceeds the number of jobs which can possibly be eliminated by technological changes. This built-in national trait can be utilized to eliminate the impact of technological unemployment as a major national issue, provided of course that management resists the attempt of labor leaders to represent job positions and classifications as well as human workers. However, as automation progresses in the short run it is apparent that considerations such as SUB will continue to be present because of the practical problems of reaching what the long run only promises.

In this respect, it is important to note that there is a common factor or concept in both automation and SUB—that concept is stability. SUB is directly aimed at obtaining stability of worker income by making industry assume part of the financial responsibility for unemployment. This is, of course, an indirect inducement for management to obtain stability of work. Factors which influence the stability of work also influence the economics of automation. This then is the answer to the question: "Is automation in any way related to SUB?" From management's standpoint the most desirable conditions for one represent favorable conditions for the other.

▶ Study of Industry

To obtain a factual picture of the thinking of management personnel on automation and SUB, and the effects on industrial organization, a questionnaire was prepared and sent to executives of 200 manufacturing concerns throughout the country. The addressees of the questionnaire were the corporation presidents. Organizations were selected that had a capitalization of a minimum of one million dollars and approximately one thousand employees. Based on the questionnaires returned, and an extensive review of literature on both automation and SUB, it appears that current experience has identified a number of basic factors which should be considered by management in preparing for the future, which might include SUB but which will most certainly include automation to some degree.

These basic factors are contained in the synopses accompanying this article. Ranging from broad generalizations to seemingly minute details, these basic considerations reflect the scope of automation and the importance of the managerial function to industrial progress.



AUTOMATION TODAY

MAKING TAPERED ROLLER BEARINGS

AUTOMATED PRODUCTION to meet expanded market requirements can establish conditions that nurture still further expansion of the market for a given product. A case in point is the manufacture of tapered roller bearings and the experience of the Timken Roller Bearing Co. in establishing a highly automated facility at Bucyrus, Ohio. Timken has promoted a product standardization program to encourage customers to purchase one of 14 bearing assemblies which are made in this plant. Result is that production in this plant is of sufficient quantity and of such economical method that the bearings can be sold at 15 per cent less than comparable items made in other Timken plants. Effect of this cost reduction is that customers see added virtue in the standardization and more are specifying these bearings.

The plant facilities make cones (inner races) and cups (outer races) from tubing and they also assemble rollers and cages (made elsewhere) to the cones to make cone assemblies. Annual production capacity is 33 million cups and 27 million cones. To achieve this output, parts flow through green machining, heat treating, and finishing departments in a continuous flow type arrangement on 11 production lines.

Immediately following the end of World War II, Timken management, engineering, and research personnel began to explore the possibilities of a straight line method of producing bearings. Costs had to be lowered, speed of production increased, and quality of product improved. Quality had to be systematically standardized, so that each bearing part produced would be of equal quality and precision.

To implement this concept of manufacture, Timken financed the development of special purpose machines to perform the operations required. Emphasis was placed on the development of smaller machines, since the range of work to be performed was much less than expected of their conventional counterparts. Quick index time was desired so that tools would not be cutting air for large portions of machine cycles. The smaller screw machines and grinders that were developed made possible considerable savings in plant space.

Timken's production engineers and bearing application engineers worked very closely with machine builders on the design of equipment supplied from outside sources. Much of the equipment was developed solely by Timken engineers.

Flow chart of processing steps shows the similarity of sequences of operations for cones and cups. Though lines are reset for different sizes of bearings being made, equipment is not shared in common between cones and cups; each product has its own series of production equipment. Each production line cost in excess of one million dollars for a plant total of $12½ million invested. It costs approximately $20,000 for tooling to equip one line for a new cup. Minimum lot size desired is two weeks run before setting up a line for another part.

When running a particular part all machines in at least one line are set up for that part and the flow of material proceeds continuously through all operations until the part run is completed. Because of differences in cycle times it is necessary to have batteries of machines perform certain operations in the process in order to keep pace with other operations.

All machines or batteries of machines in a line are linked together as an integrated production unit by conveyors, elevators, chutes, hoppers and in-process banking stages that provide flow at predetermined average rates.

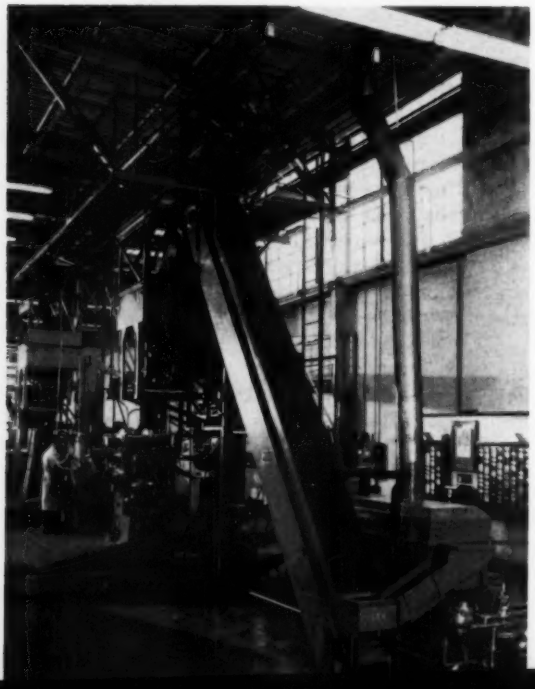
At selected intervals in the process a bank of parts is established to allow downtime for adjustment or service of one machine without affecting other machines at the same time. When batteries

1

Tubing of hot-rolled AMS 4620 is raw material for both cups (outer races) and cones (inner races) of tapered roller bearings manufactured at Timken's Bucyrus, Ohio, bearing plant. Storage area shown serves Green Machining Dept. where 16 Conomatic, 14 New Britain, and 20 National Acme automatics perform first machining and cutoff operations. Installation of crane is such that it can travel entire length of department, and also rotate 360 degrees enabling operator to turn full bundles into position required for loading machine racks. Crane was designed by Timken engineers and built by Cleveland Tramrail.

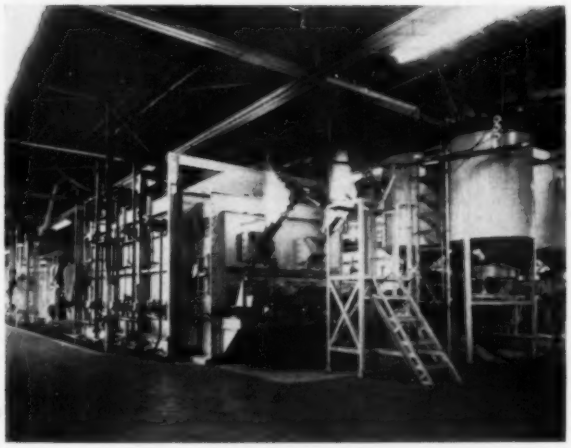
2

Battery of eight special single-spindle National Acme automatics which were designed to machine cups. Stock racks of Timken design hold an eight hour's supply of tubing. When a tube is consumed, machine stops with loading ram retracted and collet open. Attendant removes butt end and presses air valve handle, loading cradle opens, next tube rolls into cradle which then closes. Ram pushes tubing into spindle until it hits stock stop. Tubing is automatically chucked and machine resumes operation. Special collet design permits use of hot-rolled tubing with large variation of OD size, yet requires no adjustment from tube to tube. Preground, preset carbide tools are changed at predetermined intervals—fit into slides that are adjustable to obtain size on a new part being set up. Department is broken down into batteries of machines. At any particular time all machines in a battery are set up for the same part. Machine's pickoff finger puts parts on conveyor that serves all machines in battery. Chips and coolant fall to bottom of machines and into removal system. Coolant flows through sluiceway to be reclaimed and reused. Chips are separated and returned to Timken's Canton steel mill for remelt.



3

Conveyor serving battery of screw machines delivers cups to washer. After automatic wash, cups move up elevator to storage bin. Bottom of bin is equipped with rotary feeder which delivers cups to vibratory orienting platform where those that happen to be upside down fall through a half moon slot that causes them to turn over. All cups roll down a chute with the same face against one side. This orientation is checked by a limit switch escapement in the chute prior to feeding cups into a Schmidt roll-marking machine. After cups are stamped on the OD they roll on to a chamfering machine which cuts a chamfer on the ID at the face at the small end of the inside cone. Previous orientation and inspection guarantees that proper face is presented to cutting tool in chamfering machine. Parts move out of Green Machining Dept. on elevating conveyors that deliver them to hoppers that feed carburizing furnaces.



4

Five conveyors from five batteries of cup machines, and five conveyors from five batteries of cone machines go respectively to hoppers that serve four carburizing furnaces for cups and three carburizing furnaces for cones. Since it is not economically feasible to start and stop heat treating equipment, the facilities are geared to handle in seven days the same quantity of parts processed by other departments in five days. Hoppers at this point of the line provide for storage of that part of the Green Machining Dept.'s daily production that is in excess of the daily heat treat production. This accumulates to be two days heat treat requirement. Interlocked handling equipment provides for the furnaces to be fed either directly from the previous operation or from the storage hoppers. This photo shows the heat treating department for cones. Spiral retort carburizing furnaces use atmosphere of endothermic gas and natural gas at 1700 F to produce 0.025 to 0.040-inch case depth. Continuous feed through furnace takes 5½ to 8 hours.

of machines are used to perform one operation these banks also act as a distribution system to supply parts to each machine in the battery.

First-operation work is performed on automatic screw machines. Cones are processed on 4-spindle Conomatics—16 machines arranged in five batteries. Cups are machined on single spindle automatics developed for this plant—34 machines arranged in five batteries. The single spindle machines developed use carbide tooling at speeds four times higher and feeds two times heavier than before. The new models produce eight times as many cups per hour as an old model and two and one half times as many as a 4-spindle automatic. Tooling design saves 1/16-inch of stock per cup—resulting in a mile of tubing saved per month.

Spot inspection is used in this plant for machine control purposes. System is to allow parts to accumulate in outlet chutes of certain machines and to inspect one part by manual means (including optical comparator check of relief grooves in cones). The inspector then manually releases that group of parts to the conveyor leading to the next operation.

When drop release of parts or random storage in bulk hoppers loses end-for-end orientation, it is necessary to provide the handling equipment with reorienting devices before entering an operation where end-for-end positioning is critical. In resetting the lines for different size parts, not only the tooling in the machines, but also the tooling in the orienting and feeding equipment, must be changed. In some instances chutes and guide tracks must be replaced. To reduce changeover time, this circumstance has led to the replacement of flight conveyors on vertical elevators with magnetic belt conveyors that do not require a guide rail to hold the part on the flights.

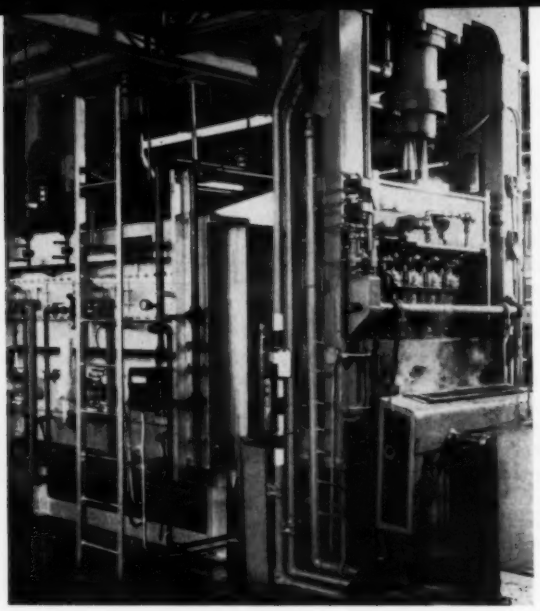
During a production run tools are changed at predetermined intervals whether they are completely dull or not. Preset tools are used and go into production at scheduled downtimes rather than on a breakdown basis. Machines are arranged for quick disconnect from the line and are taken to the tool room for machine repairs rather than having this work done in the production room.

This automated plant is manned by a staff of workers that had no previous experience making bearings. The average employee is 29 years old, has a high school education (many production employees have completed several years of college) and earns a bonus that averages 25 per cent over base pay.

All hourly-rated employees participate in the bonus system. Production line workers' bonus is based on number of pieces produced by their group. Service personnel not directly connected with a production group participate in an overall plant

5

Cross view of the center of the heat treating department for cones shows washers and double spiral conveyors that link quench tanks at end of carburizing furnaces (right) with inlet side of hardening furnaces (left). Cones are processed through carburizing, hardening, and tempering furnaces. Oil quench follows both carburizing and hardening. Heat treating equipment was developed in conjunction with Surface Combustion Corp. to provide for continuous-flow automatic operation.



6

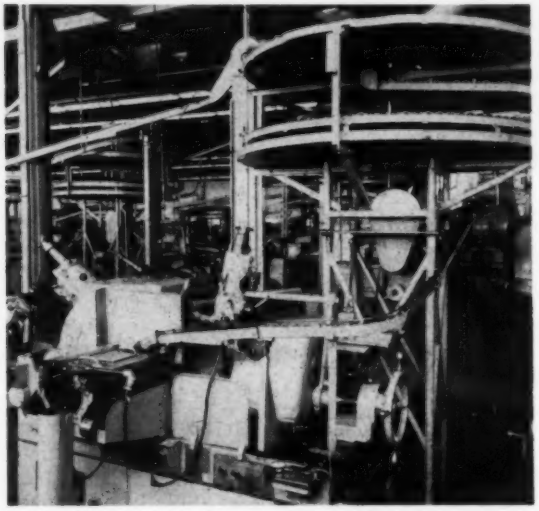
This plant employs two types of hardening furnaces to reheat parts for case refinement. Smaller parts that do not distort excessively go through spiral retorts similar to carburizing furnaces. Larger parts that tend to distort more are heated in continuous pusher type furnaces and are plug quenched. Pictured here is one of the automatically operated hydraulic quenching machines designed specially to confine cups with a die and a plug to maintain uniform ID size and minimize out-of-roundness as parts are immersed in oil.

bonus system based on an average of the group bonuses.

Supervisors and employees rotate from department to department at intervals to gain broad experience and eliminate boredom and monotony. Plant investment is about $15,000 per employee at Bucyrus and the price of each piece of equipment is posted thereon to give the worker a feeling of respect for the worth of equipment and the importance of his role in attending it.

Maintenance personnel were and are selected and trained with particular care since maintenance becomes increasingly important as the productive facilities become increasingly automatic. Maintenance employees differ sharply from the usual pattern of maintenance personnel in that, at the Bucyrus plant, each maintenance man is qualified to handle millwright, machine repair, plumbing, and assist in electrical repair problems. Since the maintenance personnel participate in the incentive bonus plan, when a shutdown occurs on any of the production lines, they move promptly to get the line back into production.

Although the cup and cone lines described in the



7

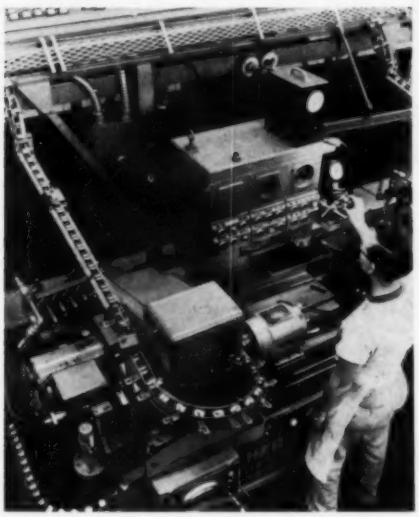
Parts are fed out of heat treating departments into finishing departments. Gardner double disc grinders finish both faces simultaneously—setups are similar for cones and cups. After face grinding, cups are rough and finish ground on OD. Shown is a #2 Cincinnati centerless grinder for finishing cups. Timken-designed feeding mechanism admits cups to a horizontal column which is kept under pressure by a system of weights. Success of automatic feeding depends upon maintaining proper pressure. Too little pressure would allow cups to fall sideways, resulting in an off-square grind. Too much pressure may cause an irregular finish on the OD. In-process float of cups between operations is accomplished in this area with spiral storage banks shown. Cups roll into spiral track and are constantly urged to outlet by brushes that rotate above horizontal trays, sweeping parts along as they pass over them.

8

General view of Cone Finishing Dept. shows lines of grinders that automatically grind conical OD of cones. Each line has a battery of machines that are simultaneously performing the same operation on a particular size cone. A belt conveyor running the length of the battery of machines is tilted such that as a workpiece progresses along this line it may roll into any machine loading chute that is not full. Cones that pass the length of the conveyor and do not enter any chute are automatically elevated to a horizontal belt conveyor that takes them back to the head of the line and discharges them to the tilted belt for another trip.

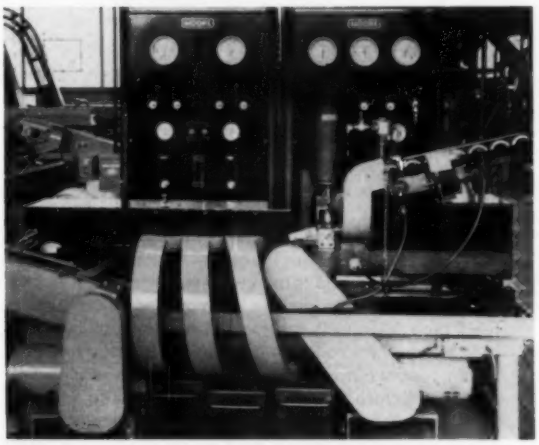
9 After OD grind, cones have their rib face ground and are moved to ID grinding machines shown here. This battery of Heald Centri-matic internal grinders is served by a loading conveyor banking system like that described in *Fig.* 8. Purpose of this arrangement is to allow each machine to be down for adjustment or servicing independently and not affect flow of material to others. These internal grinders work to tolerances of 0.0005 or 0.0008 inch, depending on quality ordered. Machine cycle time ranges from 14 to 25 seconds.

accompanying photos may be considered highly automated indeed, Timken does not consider the status quo to be the end of progress. Stated goals include the reduction in number of bearing standard sizes from 14 to 12 and reduction of bearing cost to accomplish an additional 10 per cent savings. With the ingenuity and co-operative spirit already in evidence here there is reason to assume the goals will be met.



10 Close-up of machine shown in *Fig.* 9 gives details of machine loading and discharge chutes. Cones come in from above and go out below. Grinder has automatic load, unload, wheel truing, and infeed cycles. As parts are finished they accumulate in the lower chute. Periodically an operator checks a part on gage that is mounted on machine and then manually releases chuteful of parts allowing them to roll onto a conveyor leading to an elevator that lifts them to conveyor banking system servicing next operation—honing. If size check reveals need for machine adjustment, operator makes required correction.

11 Each production line has an in-line battery of honing machines that finish the roller surface of cups and cones to an 8 rms microinch finish. This group of machines is in the Cup Finishing Dept. Belt conveyor banking system is used here too. A Westinghouse Precipitron collects oil mist from machines in this line and separates air and oil. In the process abrasive tape is indexed to present a fresh surface to each part. Machines are of Timken design; complete automatic cycle in from 8 to 12 seconds, depending upon size of cup.



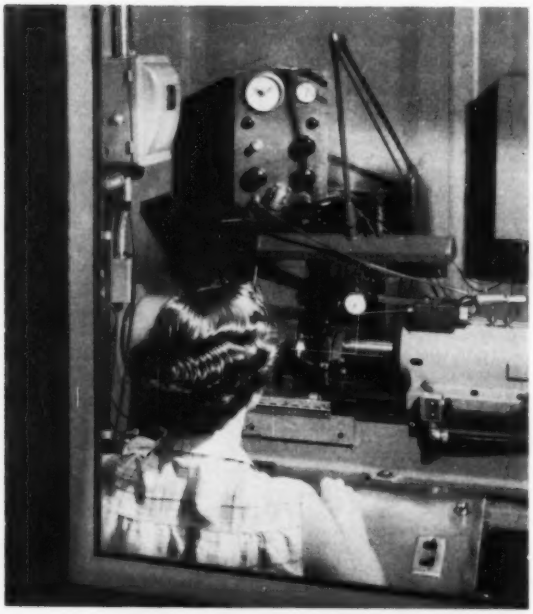
12 At the end of the finishing lines, cups and cones are automatically inspected 100 per cent. This Moore automatic gaging machine for cones measures overall length, OD, raceway size, taper, rib length, and bore. Gage is both electrically and pneumatically operated—checks 42 cones a minute. Cones roll in from storage on chute at right and go out on conveyor at left. Rejects go into baskets according to measured conditions.

13

Conveyors from automatic cone inspection gages take parts to visual inspection tables. Six inspection lines handle output of the five cone finishing lines. Cones roll around on S-shaped track that inverts them in the process, enabling inspector to see all sides of each part passing by. Parts with visible defects not apparent to dimensional gages are removed from lines at this point. Similar stations at end of cup lines have sound deadening side panels to reduce noise level. Inspectors are shifted to other work in finishing departments every four hours.

14

Cone assembly machine is semiautomatic. Rollers and cages are made in other Timken plants, and shipped as finished parts to these assembly operations. Two-station fixture is mounted below roller feed tube. Cage is rotated under tube until all slots are filled with rollers. Pivoted strip mounted between fixtures stops flow of rollers as tube is swung to other fixture. Cone assembly is placed in press that closes cage, which retains rollers around cone. A photoelectric beam is broken by operator's hand placing the assembly into press fixture. This action sets and trips press. Finished assembly is automatically ejected into a conveyor. Operators can complete as high as 1200 cone assemblies in an hour.



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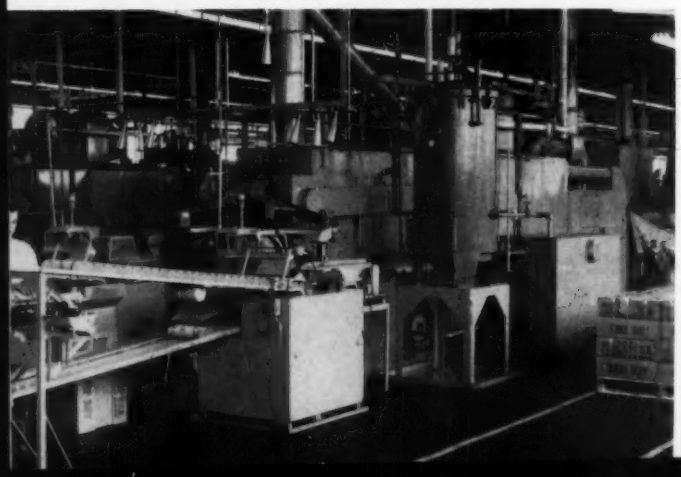
Cone assemblies are tested for noise in enclosed soundproof booths. When assembly is run at high speed under force, operator can tell by sound whether it is good or not. In addition to this test a gage measures taper size and runout of the assembly.



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Entire unit of final inspection (right), washing, drying and slushing (center), and packaging (left) of cone assemblies is shown. Slushing operation coats the cone assemblies with a rust preventive called petrolatum. Cone assemblies are packed into cardboard tubes by the machine and attendant seals the tops. Cone assemblies are shipped without cups since assemblies are interchangeable and these items are usually sent to different plants.

SERVO VALVES

AND AUXILIARY HYDRAULIC EQUIPMENT

This fourth part of a series covering the synthesis of hydraulic control systems from commercially available components describes major types of servo valves and some of the factors influencing their selection. Also described are some of the auxiliary components and items of plumbing often used in hydraulic systems of all kinds.

By **R. HADEKEL**, Engineering Mgr., Sunbury Div., Sperry Gyroscope Co., Ltd., Brentford, England

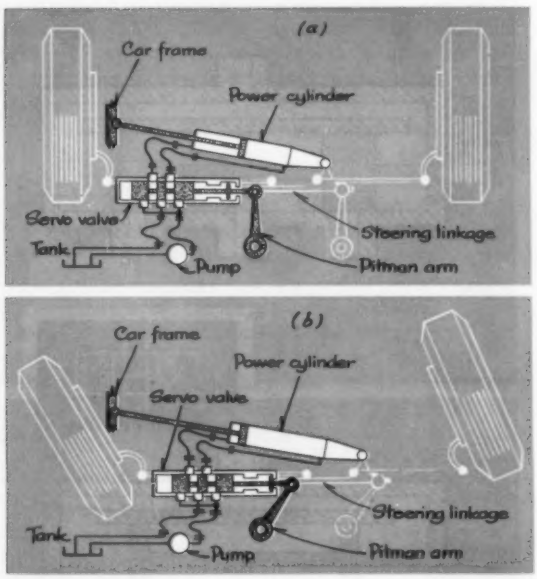


Fig. 36—Diagram of hydraulic vehicle steering system illustrates use of mechanically operated servo valve and power cylinder. Oil pressure is equal on both sides of piston in straight ahead position (*a*). Pitman arm operates valve slide to admit pump pressure to one side of piston and vent other side to tank in left turn position (*b*). Turning motion of wheels stops when valve body, carried by steering linkage, rebalances pressure in selected position. Floating valve body thus provides virtual feedback to close control loop.

SERVO VALVES may conveniently be divided into mechanically, pneumatically, and electrically operated types. The former are usually employed in comparatively elementary servo systems such as aircraft power controls, vehicle steering devices, *Fig.* 36, and copying lathes, *Fig.* 37. Electrically operated servo valves, i.e., valves operated by some form of torque motor, are more often applied in elaborate systems such as those required for tape-controlled milling machines.

Cylindrical slide type valves, which are the selectors most commonly used in servo applications, bear strong resemblances to ordinary directional control valves. However there are several important differences between the two. For example, directional control valves have a clearly defined neutral position which extends over an appreciable portion of the valve slide stroke. In closed center valves it is an overlap; in open center versions it is an underlap, *Fig.* 38. Servo valves on the other hand are designed to act almost immediately the valve slide is moved away from neutral. Otherwise the servo system would exhibit a large dead zone, or area of reduced system gain, which would mean reduced accuracy. Dead zones may be permissible in certain noncritical servo applications, but they should always be small.

Another important distinction between directional control valves and slide type servo valves is

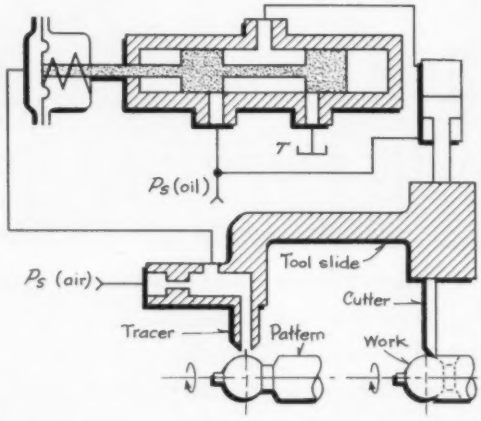


Fig. 37—Copying lathe uses hydropneumatic servo system to control motion of cutting tool in accordance with variations in contour of plaster pattern. Tracer does not contact pattern.

in their respective flow characteristics. Directional control valves are designed to be *Off-On* devices. That is, the ideal valve of this type would be shut tightly, open instantly, and give minimum restriction to flow when fully open. Servo valves however function by permitting progressively greater amounts of flow as the valve slide is moved away from neutral. Flow characteristics for ideal valves of both types are compared in *Fig.* 39.

The fact that the maximum port opening in a directional control valve may be excessive need not rule out the possibility of its use in simple servo installations. Slide travel can always be limited by stops to prevent maximum opening being reached. But *rate* of opening is also a factor, and even though one might obtain satisfactory flow control by interposing a suitable lever arrangement or other mechanical gearing down, this is not usually convenient.

Concerning adaptations however, there is on the market a range of valves designed primarily for power steering of vehicles, and these should be usable as mechanically operated servo valves for many applications in the control of automatic production machines.

Where servo performance requirements are stringent however, specially designed valves are necessary. In such cases "laps" may have to be held to accuracies substantially under 0.001 inch, and variation of port opening with valve slide displacement may have to be absolutely linear. (The latter condition, incidentally, rules out use of valves having liners with large round holes for ports.)

Electrical Operation

Electrically operated servo valves for low power have been made for many years for process control applications. The outstanding example for hydraulics is the Askania nozzle valve, *Fig.* 40. Kinetic energy of the fluid at the nozzle exit is reconverted to pressure in the tapering passages of the receiving block in this device. Pressure reconversion is virtually complete.

An electrically operated pneumatic servo valve is the flapper valve, *Fig.* 41. This type is normally used in conjunction with a fixed orifice to produce variable pressure rather than variable flow, but the two are interrelated.

The development of high power, high performance servo valves stems largely from missile requirements. Characteristics of servo valves are seriously affected by the forces which must be overcome by the torque motors in this service. In order to reduce the forces the present trend is to use two-stage valves, the first of which acts as

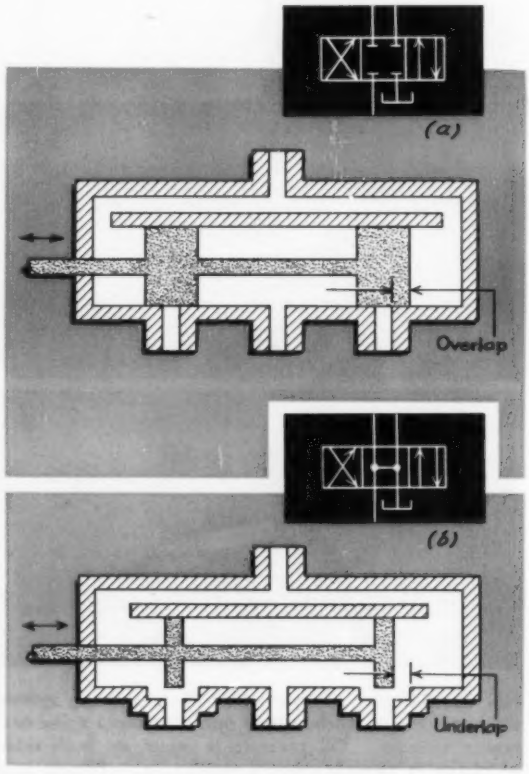


Fig. 38—Ordinary directional control valves have a clearly defined neutral position that extends over an appreciable portion of valve slide stroke. Closed center types *(a)* have overlap; open center versions *(b)* have underlap. Control valves for servo applications require minimum "laps" to avoid dead zones.

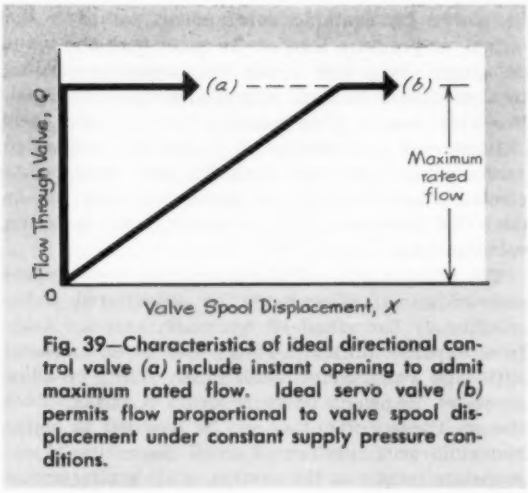


Fig. 39—Characteristics of ideal directional control valve (a) include instant opening to admit maximum rated flow. Ideal servo valve (b) permits flow proportional to valve spool displacement under constant supply pressure conditions.

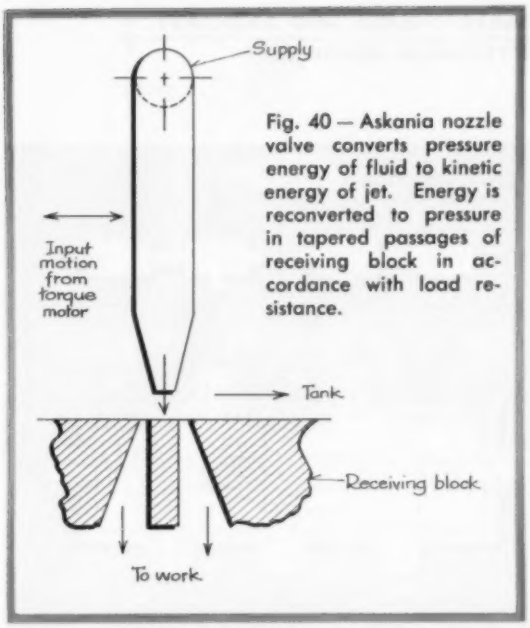


Fig. 40 — Askania nozzle valve converts pressure energy of fluid to kinetic energy of jet. Energy is reconverted to pressure in tapered passages of receiving block in accordance with load resistance.

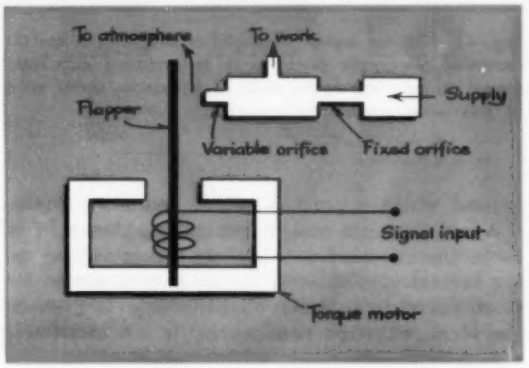


Fig. 41—Pneumatic flapper valve provides variable pressure at work connection as determined by position of electrically operated flapper with respect to orifice.

a preamplifier. The torque motor drives the first stage, which need handle only enough power to operate the second stage. The first stage valve therefore can be designed to have low friction and hydrodynamic forces.

Several such valves are on the market. One type, *Fig.* 42, makes use of a flapper valve first stage which, together with fixed orifices, produces two variable output pressures. These pressures, applied to small pistons at opposite ends of a slide type servo valve, operate the spring-centered slide. Motion is proportional to the applied pressure differential and in a direction away from the stronger input pressure.

Another type, *Fig.* 43, uses plain mechanical servo follow-up action between first and second stages. There are many possible constructional variations of this two-stage servo valve. Still another type includes feedback by means of a spring between the main and preamplifier valves. Action in this case is based on the force displacement characteristics of the input torque motor.

Most of these valves are of the 4-way type, i.e., suitable for the control of double acting hydraulic cylinders or motors. They can be used for controlling single acting devices by leaving one of the output ports blocked and unused.

▶ Servo Valve Properties

Important characteristics of servo valves include: 1. Static characteristics, or the plot of output flow versus differential output or load pressure for various values of torque motor current. 2. Output flow for zero load pressure versus torque motor current, with particular emphasis on threshold or small-signal performance. 3. Frequency response under a harmonic input, together with phase shift.

The characteristic of output flow versus differential pressure, which establishes the manner in which flow varies with load resistance, is of great importance from the viewpoint of servo stability. Good stability may or may not be difficult to achieve according to whether or not the system has substantial inertia and flexibility. Other factors influence stability but their discussion is not within the scope of this presentation. Generally speaking, a falling characteristic which causes a reduction of flow as load increases, is favorable to stability. This has the drawback however of making the servo system more sensitive to friction loads, and a balance therefore should be sought.

Threshold characteristics have obvious importance if high accuracy is desired. It is generally possible to improve threshold or small-signal performance by boosting the servo gain. This may be done in the electrical portion of the loop, but this method is feasible only within certain limits

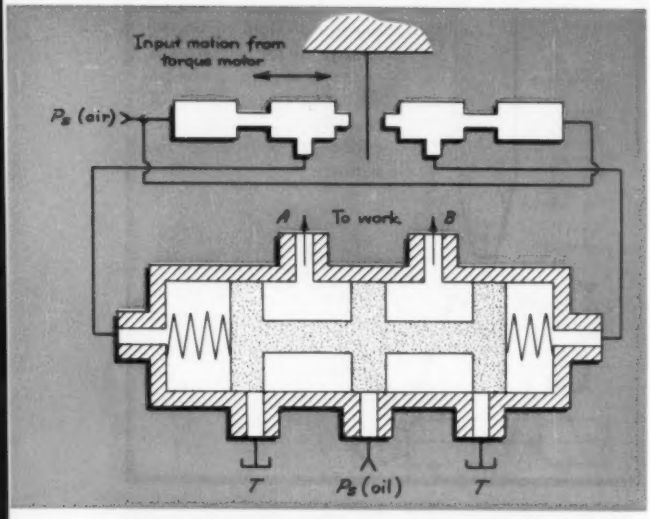


Fig. 42—Flapper valve preamplifier stage develops differential pneumatic pressure in accordance with input signal to operate valve slide of hydraulic servo valve in this two-stage arrangement.

beyond which a practical servo becomes unstable.

Apart from its use in evaluating threshold effects, the curve of output flow versus torque motor current is of interest for its general shape. For most purposes a linear characteristic is probably the ideal, although nonlinearity is not necessarily a serious disadvantage in some applications.

Frequency response of the servo valve acquires meaning only when related to the required performance of the servo system as a whole. If the servo is linear, the output will be harmonic under an input that varies sinusoidally with time, though of different amplitude and phase. The ratio of output to input amplitudes, together with the phase angle, comprise a measure of harmonic response of the servo valve for a given frequency. Attenuation must be moderate over the frequency range of interest, but moderate phase shift is often of greater importance.

All of the foregoing comments on servo valve characteristics are necessarily generalities which can only draw attention to some of the points of interest. Whenever possible a full analysis of the complete servo system should be made using established servo theory. Data on valve characteristics as well as characteristics of the remainder of the system, particularly those of the load, should be available. With this information and a thorough analysis the designer will be able to make the best selection of a servo valve.

It is interesting to note that relief valves, reducing valves, and metering valves may be regarded as self-contained closed loop systems. The relief valve, for example, continuously compares the output or pressure load on its spool with the input or spring load, and opens its passage according to their difference until output and input are equal. For this reason it is possible to duplicate their characteristics by means of electrically controlled servo valves, pressure pickoffs, and appropriate electrical circuits. *Fig.* 44 shows how this can be done to produce relief, reducing, and metering valve actions.

The foregoing is not to suggest that servo valves and additional components be substituted indiscriminately for standard hydraulic valves. Aside from expense, difficulties may also be encountered with lags which could result in instability or allow excessive transient pressure or flow peaks. Even though these difficulties can be avoided by using hydraulic accumulators of small capacities at appropriate points in the system, such arrangements are not necessarily practical in all cases. Rather, their use should be confined to those special cases where extreme accuracy of control is required.

Above all, these alternate means of providing relief, reducing, or metering action are presented in illustration of a line of thought which might prove of value in cases requiring a degree of pressure or flow control that is unattainable through use of standard automatic acting valves.

▶ Connections and Mountings

At this point it is appropriate to mention connecting and mounting arrangements that are commonly available in commercial hydraulic valves of all types. Most valves are available with screw type pipe connections, and in larger sizes also with flange connections. Relief valves often have double inlet connections which avoid the necessity of providing separate pipe tees. Check valves are available with inlet and outlet openings in-line or at right angles. The latter arrangement is often convenient to avoid an elbow or a bend in the pipe.

Mention has previously been made of stacking valves which are arranged to be interconnected internally by channelings and drillings, leaving only

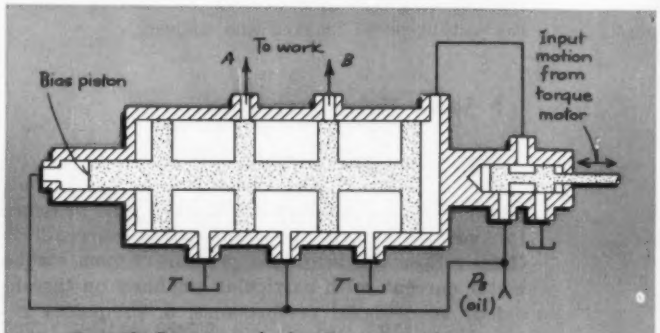


Fig. 43—Two-stage hydraulic servo valve contains small valve to actuate slide of larger valve.

screw connections to be made for pressure, tank, and actuators.

Pad-mounting valves are a very useful type for achieving neat installations. In this type pressure, return, and cylinder connections come out to a flat face as plain holes surrounded by *O*-rings. Such valves are intended to be mounted on a pad that is common to other valves of the same mounting type. Holes in the pad register with those on each valve. Required interconnections can be achieved in various ways. For example, the common pad may have plugged drilled holes, cast-in passages, or it may be electroformed to provide passages. Other means of interconnecting include fabrication of a pad from precut lengths of tubing by welding or furnace brazing, or by ordinary piping at the back of the pad. The latter does not necessarily result in any marked improvement in neatness over ordinary installations, but does allow major portions of the hydraulic system to be fabricated as a separate unit.

With pad installations it is seldom possible to include pilot valves or cam-operated valves on the pad—these are piped in the ordinary way.

Electrohydraulic servo valves are frequently made so they can be pad mounted directly to their actuators. Apart from neatness and accessibility considerations this arrangement keeps down the volume of oil between the actuator and its valve, with consequent benefit to servo stability.

Pressure Devices

Pressure switches are used in cases requiring electrical contact make-or-break action in response to pressure conditions in the hydraulic system. Ordinary pressure switches close (or open) when a predetermined pressure is reached and reopen (or reclose) when there is a drop in pressure below a predetermined level. Differential pressure switches are also available. These reset only at a definite margin below the operating pressure. Settings are usually adjustable for both types.

Differential pressure switches are useful for operating unloading valves and holding them open until a desired reduced pressure level is attained. Both ordinary and differential types may be used in automatic sequence systems as will be described in a subsequent part of this series.

Pressure pickoffs are transducers that give electrical outputs proportional to the applied pressures or to the pressure difference between two connections in the case of differential types. They may be required in certain servo systems. More often however they are used as part of the basic instrumentation for studying the behavior of components and systems. Their ability to follow rapid pressure transients is an asset here.

Pressure pickoffs have been built that employ capacity, inductance, or resistance (strain gage) elements. In one design of the resistance type there are four elements arranged in a Wheatstone bridge circuit to overcome drift that would otherwise be induced by temperature effects.

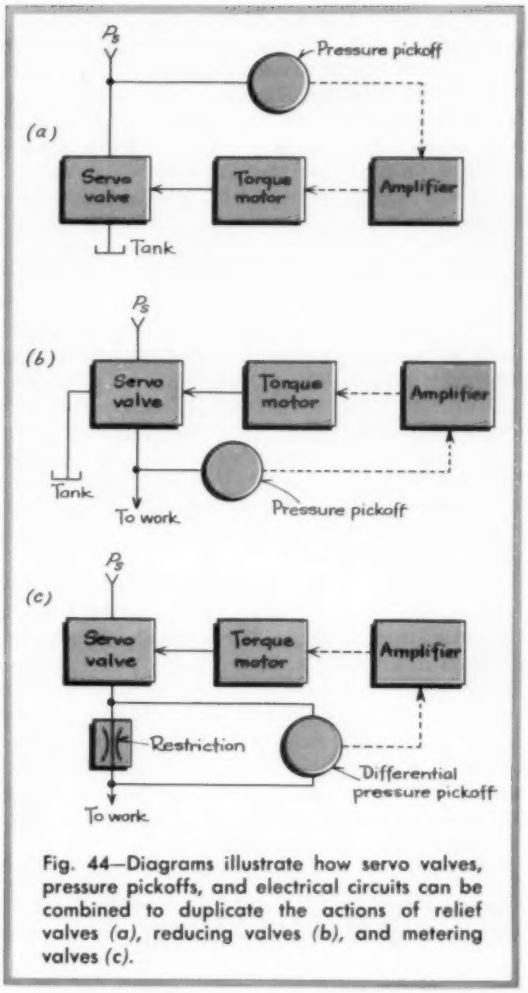


Fig. 44—Diagrams illustrate how servo valves, pressure pickoffs, and electrical circuits can be combined to duplicate the actions of relief valves (*a*), reducing valves (*b*), and metering valves (*c*).

Accumulators and Filters

Hydraulic accumulators are used to supply instantaneous and peak demands for high pressure fluid, as during noncontinuous work-cycles. Because of their energy storing abilities, these components permit use of relatively low power pumping equipment in circuits having intermittent duty cycles, by using the time between withdrawals for replenishment. Secondary applications include use for pulsation and shock absorption, and compensation for internal and external leakage and the effects of fluid temperature variations.

Accumulators may be classified into separator and nonseparator types. Separator types effect isolation of hydraulic fluid and compressible gas by means of bags or diaphragms. In nonseparator types, or plain pressure bottles, the two media are in intimate contact.

Separator type accumulators are available in a range of capacities usually adequate for all but very large installations. For these cases it is nec-

essary to use a battery of such components, which is expensive and often inconvenient, or to go to nonseparator type pressure bottles. The latter have two drawbacks. First, the gas gradually becomes dissolved in the oil and must be replaced periodically by recharging. Second, if the system pressure drops below the value at which the accumulator will be empty of oil, gas may enter the system. This occurrence can be prevented, but requires the addition of pressure and fluid level sensing devices and safety shutoff controls and valves.

Filtration of foreign particles from the hydraulic fluid is necessary to prevent excessive wear of components and to minimize clogging of control adjustments. The main types of filters available are wire mesh, which is comparatively coarse, and so-called micronic. The latter type provides filtration of very fine particles, but at the expense of greater bulk. Filtering elements of micronic filters are usually made of specially treated paper or porous sintered metal.

There seems to be no general consensus or uniform experience as to the degree or even type of filtration that is best. For example, it may be questioned whether a filter in the pump suction line is adequate, although this is taken for granted in most industrial installations. Perhaps there can be no general rule since different pumps and valves vary in their sensitivity to dirt. The best advice the author can give is to stick to the equipment manufacturer's recommendation unless there is good reason to do otherwise.

▶ Heat Exchangers

Heat exchangers are used when it is necessary to remove excess heat from the oil in the hydraulic system. They are frequently required, since in many industrial systems the power dissipation is such as to preclude sole reliance on convection cooling at the tank and pipes. An average dissipation of 1 or 2 horsepower would appear to be the limit on indoor installations beyond which forced cooling becomes necessary. Both fan and water cooled heat exchangers are available, the latter in higher capacities.

From a design standpoint there are many ways of reducing power dissipation in hydraulic systems, some of which will be described in a subsequent part of this series.

Pipe fittings and flexible hoses are well-established components which need no extensive comment. There has been a trend of late toward rotary joints as an alternative to flexible hoses. Where feasible, their use could lead to neater installations. The question of relative reliability of flexible hoses and rotary joints is worth pondering, but the author has no data on which to base an answer.

There are several proprietary self-sealing couplings on the market, and their use should be contemplated for points in the circuit where connections have to be broken for maintenance purposes or other repetitive routines.

Fifth part of this series, to cover principles of hydraulic systems engineering, will appear in the April issue.

Bulk Material Slinger

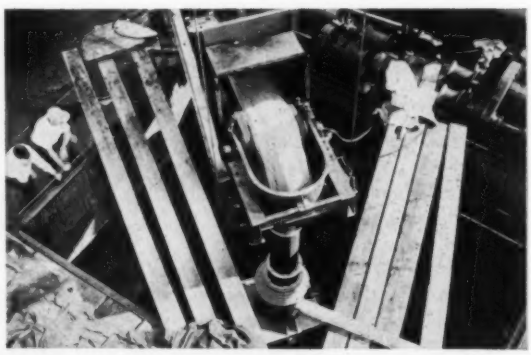
SUITABLE for many bulk materials, including refined sugar, salt, grain, feed, fertilizer, and sand, the Link Belt Co. Jetslinger can handle up to 700 tons of material per hour—depending on the density of material handled.

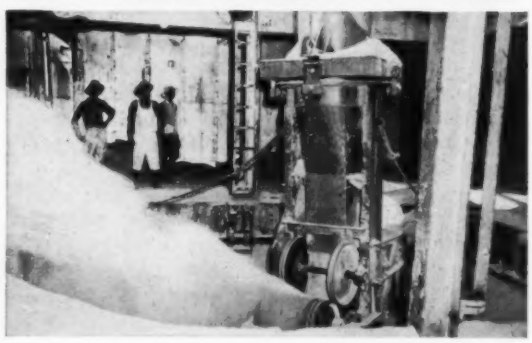
A Jetslinger is composed of a short endless belt operated over two pulley drives at high speeds (lower photograph). Idler wheels form the conveying arc and the trajectory angle, which can be adjusted by raising or lowering the front pulley. A chute above the unit directs bulk material onto the rear slope of the belt as it travels around the short conveying arc at high speeds, discharging the material by centrifugal force.

Basically, the Jetslinger can be used to increase ground storage facilities, to increase or utilize to a maximum warehouse storage capacities, or to load and trim enclosed carriers such as boxcars or cargo vessels with a minimum of auxiliary equipment and manpower. Under certain conditions, the unit can throw material a distance of 90 feet or pile it to a height of 35 feet above the Jetslinger.

Four Jetslingers that hurl raw sugar from a belt conveyor into storage and from storage into the hold of a ship have solved a unique set of handling problems for the operators of a sugar loading dock in San Juan, P. R.

For the sugar handling problem, two of the devices are used within the warehouse to sling sugar into storage piles, permitting full use of limited space. Two other units are used in loading ocean-going vessels by directing flow of raw sugar to all areas of the hold. When a unit is in operation deep inside the ship's hold, a telescopic chute directs the sugar to the Jetslinger.





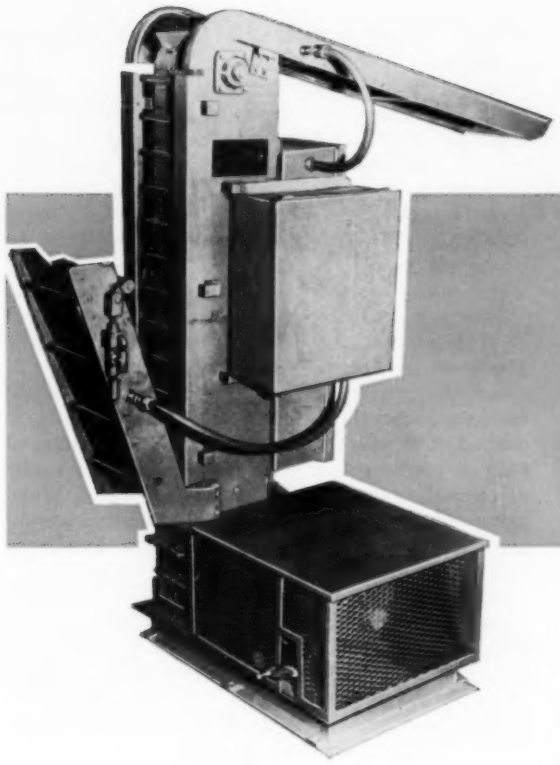


Fig. 1—Use of two proximity pickups in the control of an elevating conveyor is shown in this photograph. The elevator, built by Feedall Inc., is used to automatically feed parts from a tube cutting machine to a deburring machine.

APPLYING PROXIMITY TRANSDUCERS

By DAVE ELAN
Chief Engineer
Electro Products Laboratories
Chicago, Ill.

Machine control systems frequently require means for detecting the presence or passage of metallic workpieces or machine elements. A basic development in sensing arrangements for such systems is the use of proximity transducers. Information on applications of these sensory devices is set down in this article.

SENSING SYSTEMS using proximity transducers are proving to be low cost, time-saving solutions to numerous machine control problems. They can be used to initiate, control, or terminate some action when a mass, such as a workpiece or a machine element having metallic properties, comes within the field of a transducer.

Such a transducer system includes a proximity transducer, a shielded connecting cable, and a control unit. When any mass having metallic properties comes within the field of the transducer or pickup, it alters the energy characteristics of a specially designed coil. The proximity control unit senses this change in energy characteristics and produces electrical pulses to trigger associated equipment or devices. The units operate independent of speeds or spacings within the range of the equipment.

Proximity control units are generally available as standard sensitivity or extra sensitivity models. Pickups are available in a variety of sizes and shapes to meet various requirements. Generally speaking, the smaller diameter pickups are best suited to detection of small objects at close distances, while larger diameter pickups can sense larger objects over greater distances. For general applications where space is limited and normal sensitivity required, a stock screw-in type pickup is available. Maximum operating clearance for such units may be up to $\frac{1}{8}$ inch depending on the material to be sensed. Another type provides extra sensitivity by means of a larger diameter coil and has a maximum operating clearance up to $\frac{3}{8}$ inch.

For counting small and medium sized metal parts, a hollow coil pickup is appropriate. The parts to be counted are dropped or permitted to slide through the coil. For sensing large masses at greater distances, a pickup with a pancake coil does the job. Coil diameters up to 12 inches or more can be supplied. Generally such a pickup is designed to sense a specific object and to operate over a range equal to its coil radius.

Some Dos and Don'ts

In the application of proximity transducer systems, an important consideration is to allow suffi-

cient distance between the pickup and extraneous metal surfaces. Make sure that sufficient clearances to sides and back of pickup exist. Usually, a minimum distance equal to the coil radius is necessary for clearance around the pickup.

Provide enough space between pieces to be counted to allow the pickup to recover before the next part approaches. Otherwise, the result will be a continuous register in the control unit. When electromechanical counters are used, the parts must be made to pass through the coil slowly enough to give the counter time to operate.

Make sure when using hollow coil pickups that the parts being counted pass through the coil slowly enough to permit the relays to act. By slow speed, we mean 600 parts counted per minute. High speed pickups can count as high as 3600 per minute. The speed of parts through the pickups is directly related to gravitational pull, and by controlling the incline of the pass-through chute, the speed of the parts can be adequately controlled. Another important point with regard to use of hollow coil pickups is to select a coil of small enough diameter to detect the work planned.

Do not attempt to operate a pickup with a connecting cable varying by more than 50 per cent from the standard length for the unit. This length is a critical part of the circuit, and the system will not function properly if too great a deviation is made. Transducers with special length cables can be obtained.

Arrange for parts to come as close to the pickup as possible without touching it, as this will permit the least critical control setting and more reliable operation.

Make sure that the proper control system is used. For example, in machine applications where coolants and cutting oils are used, it is desirable to have the control units mounted in enclosures conforming to standards of the National Electrical Manufacturers' Association or the Joint Industry Conference. The cables should be potted into the pickup to provide a waterproof seal and prevent water from shorting the coil.

Economic considerations in the application of pickups suggest the use of low-speed relay units wherever possible. Their only limiting factor is speed, but they are versatile enough to handle most applications satisfactorily. If long life is desired, it is wise to specify a control unit equipped with a mercury contact relay. These can easily accommodate more than a billion operations. When using this type of contact, special caution should be taken to properly protect contacts with suitable filters for the particular load involved.

Frequently, applications may require modifications of control units with time delays; i.e., to stop a machine when parts pile up in front of a pickup. Control units can also be modified to operate external power relays. This eliminates the built-in pilot relay required to operate electromechanical counters and registers.

Specific Applications

One of the first proximity transducer systems sold by our firm went to a spring manufacturer. The pickup was used to sense the end of each spring coming out of the spring winder. The end

Fig. 2—A hollow coil transducer controls a vibratory bowl feeder in this illustration. The feeder, built by Perry Equipment & Engineering Co., is started and stopped in response to the level of the pins in a feed tube which passes through the pickup.

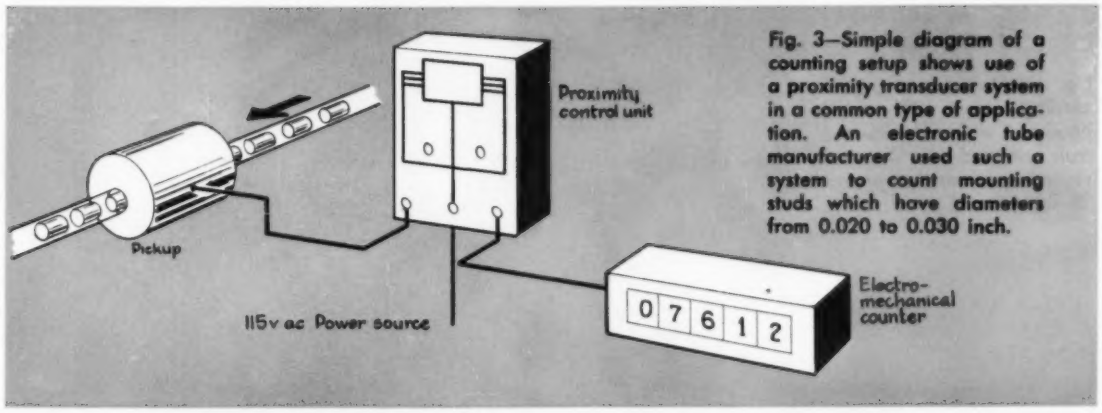


Fig. 3—Simple diagram of a counting setup shows use of a proximity transducer system in a common type of application. An electronic tube manufacturer used such a system to count mounting studs which have diameters from 0.020 to 0.030 inch.

of the spring energized a cutter which cut the spring to the right length. This same basic idea has been adapted for cutting rods, tubes, and lengths of other metallic forms.

Another, more unusual, installation involved the controlling of the arc in an automatic welding machine for butt welding joints. The transducer system turned the arc on when the welding head was in place over the metal joint to be welded, and turned it off when the other end was reached and the weld was completed.

A natural application of proximity transducer systems is to automatic feeding arrangements such as shown in *Fig.* 1 and 2. The arrangement in *Fig.* 1 uses two transducers to control a tube cutting machine and the elevating conveyor which takes cut tubes from the cutting machine to the feed chute of a double-end burring machine. One pickup controls the tube cutting machine and automatically shuts it off when the chute to the elevator is filled. The other pickup controls the elevator and shuts if off when the chute to the burring machine is filled.

In *Fig.* 2 a hollow coil pickup is used to control a vibratory bowl feeder. The pickup is installed around the feed track from the feeder. When the track fills to the pickup, a time delay of approximately two seconds is provided, which allows the track to fill to the top, and then the feeder is shut off. As soon as the parts level in the track is reduced below the pickup, the feeder is restarted.

Use of a hollow coil pickup by an electronic power tube manufacturer to count the tiny studs for mounting vacuum tube elements is illustrated by *Fig.* 3. These studs vary from 0.020 to 0.030 inch in diameter.

An automotive manufacturer is using a proximity pickup system to sense gears as they move along on a conveyor. This particular operation involves the manufacture of an automatic transmission. As the gears are sensed by the pickup, a motor is energized which causes the gears to be moved onto a spindle for further processing.

Another very interesting application was developed for the problem of a machine tool and equipment manufacturer. In one particular operation the company drills six holes simultaneously. An automatic warning system was devised to insure proper drilling of holes. A phenolic frame was made to hold six hollow coil pickups, *Fig.* 4. If any of the drills break, the occurrence is detected by the related pickup and the drilling machine is stopped. Each of the coils is encapsulated so coolants can flow over them without shorting them.

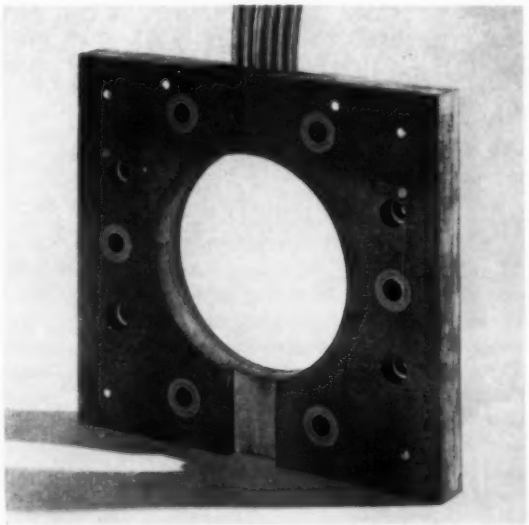


Fig. 4—This phenolic plate with six imbedded hollow coil units was designed for use on a drilling operation where six holes are drilled simultaneously. The pickups sense the breaking of a drill and automatically shut off the machine.

As the trend toward automated production lines continues, the applications for these sensing systems will increase by leaps and bounds. In a continuous production line operation which requires frequent starts and stops, they should prove especially advantageous.

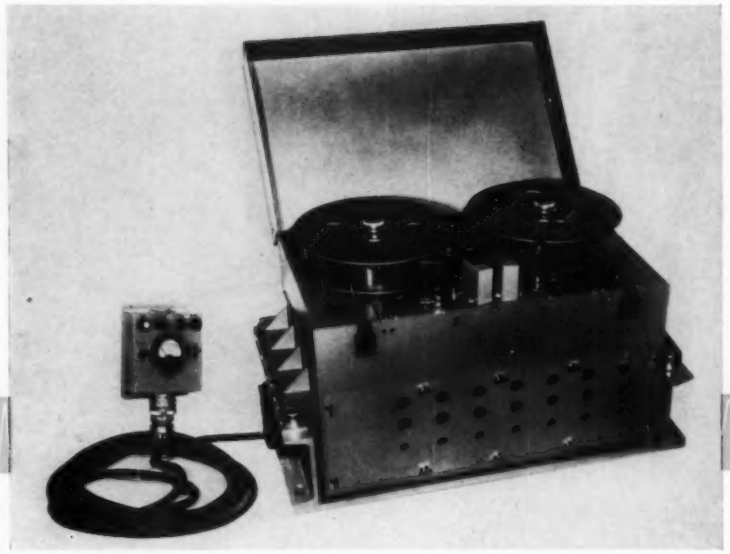


Fig. 1—Magnetic tape recording system. This unit is equipped with a remote control unit and two 14 track recording heads that provide 28 interleaved tracks.

MAGNETIC TAPE SYSTEMS FOR DATA RECORDING

By PHILIP A. MOHR
Engineering Operations Section, AGT Div., General Electric Co., Evendale, Ohio

TREMENDOUS progress has been made in the field of instrumentation within the past few years. A device which has contributed greatly to this progress—perhaps more than any other device — is the magnetic tape recorder. Through the use of magnetic tape and the magnetic tape recorder, it is now possible to record data in a form which permits automatic reproduction from a transducer to the final form of the data. A phenomenon can be described by the transducer, this intelligence recorded on magnetic tape, and finally reproduced in usable form by automatic means such as time history plots, x-y plots, and tabulated numerical data.

The magnetic tape recorder is not a solution for all data recording problems. However, it is worthy of particular consideration when there is a lot of data to be recorded requiring rapid processing, and when frequency response is a limitation of other methods of recording.

Basically, a magnetic tape data recorder is a device to transport tape over a recording head at a constant speed, *Fig.* 1. The tape is a flexible ribbon of plastic which is coated with particles of magnetizable material. The recording head is a transducer capable of generating a magnetic flux of which the density is a fuction of the instantaneous value of the applied electrical signal. Variations in magnetic flux from the recording head are imparted to the magnetizable particles contained in the tape.

The recorded track on the tape may be regarded as a continuous train of varying flux density. In this state, the record is a flux density analog of the original applied signal or intelligence. To obtain this intelligence from the recorded form, the tape must be passed over a detecting or playback head. In this process, the variations in flux density are converted to an electrical signal.

The playback head is a differentiating device—sensitive to the rate of change of flux density—hence, the output diminishes rapidly at the very low frequencies. The high frequency recording limit of the tape depends largely on the speed of tape transport during the recording process. Other factors enter into this such as the particle size in the tape, the recording head gap, thickness of the magnetic layer in the tape, head design, and special recording techniques. Generally speaking, the maximum number of cycles which can be contained in one inch of tape track is about 1,000 to 1,500. For example, at a tape speed of 30 ips the upper freqency limit is about 30,000 to 45,000 cps.

Four typical schemes of recording intelligence on magnetic tape will be discussed in this article.

Specialized requirements have led to the refinement of techniques for magnetic tape recording of data in aircraft engine development. Considering the readily apparent and expanding role of magnetic tape in the field of automation in general—it is apropos that this successful specialized application be reviewed.

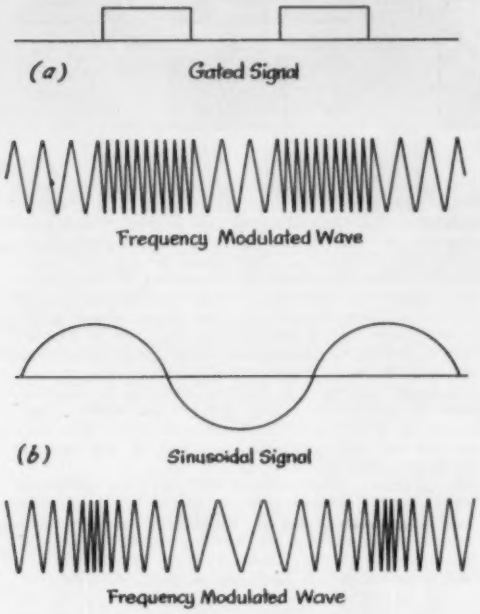


Fig. 2—Frequency modulation of a signal is provided by varying the instantaneous frequency of a carrier wave by an amount that is proportional to the amplitude of the modulating signal and at a rate proportional to the frequency of the modulating source. Modulation by two types of signals is shown.

They are digital, FM carrier, pulse width modulation (PWM), and direct.

Digital Recording

Digital recording is potentially one of the most accurate methods of recording data. In this process, a number of schemes may be employed. Usually, the information is impressed on the tape by using a straight binary code in the form of pulses. The pulses are recorded in parallel on a multitrack tape. In order to avoid pulse dropouts due to tape imperfections, the width of the tape may be limited to about ¾ inch. Based on a standard tape length of 2400 feet, it would be possible to record data over a 60 minute interval at a tape speed of 8 ips. This would result in a sampling rate of about 800 words per second, with a word being defined as one data reading comprised of two decimal digits.[1]

There are some undesirable features associated with digital recording. For instance, the information must be commutated to permit multidata and multichannel recording which reduces frequency response to a relatively low level, and equipment required for analog playback is quite complex. Virtually all data should be played back into analog form prior to digital tabulation since data in digital form often defies editing or proper evaluation.

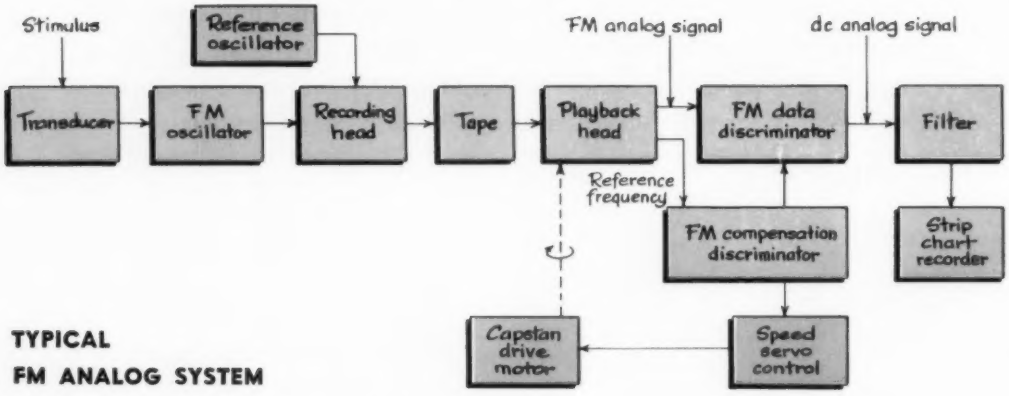
FM Carrier Recording

Frequency modulated carrier recording is one of the principal methods of recording data on magnetic tape. The main reasons for this are:

1. Transducers are available which are easily applied to the FM carrier system and are adaptable to portable applications.
2. FM is adaptable to radio-telemetry systems.
3. Presently available magnetic tape recording machines have low flutter characteristics and playback equipments are designed to compensate for the effects of flutter on the recorded track.
4. Digital playback of FM data may be accomplished at equivalent or better accuracy than obtainable with a digital system.

Frequency modulation is produced by varying the instantaneous frequency of a carrier by an amount that is proportional to the amplitude of the modulating signal and at a rate that is proportional to the frequency of the modulating source.[2] To graphically illustrate this principle, suppose that a telegraph dot and dash have been applied to an FM system. The modulating signal and the modulated wave are shown in *Fig. 2a*. If the applied signal is sinusoidal, then the

[1]References are tabulated at end of article.



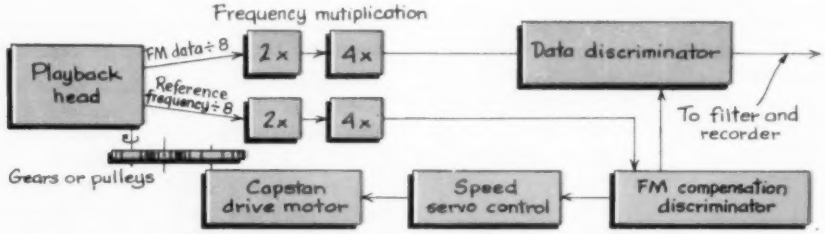
TYPICAL FM ANALOG SYSTEM

THIS system is equipped to record FM analog signals and play back these signals as plotted results. As shown, a transducer produces a voltage analog of the stimulus. The voltage is introduced to an FM oscillator which converts the voltage analog to a frequency analog of constant amplitude. This is then impressed on the tape with a recording head. Simultaneously with the data channel record, a precise frequency from the reference oscillator is recorded.

The varying levels of magnetic flux density on the tape are detected by the playback head and the FM analog signals which were recorded are reproduced. These FM data signals are then introduced to FM data discriminators. The output of each discriminator is an electrical signal whose sense and magnitude is a function of the deviations of the applied FM signal from its center or carrier frequency. As data signals go to the data discriminators, the reference frequency is simultaneously fed to the FM compensation discriminator. The reference frequency is discriminated or demodulated in the same way as the data channel. The output of the reference discriminator in this case is a function of the tape speed variations which modulated the reference frequency during recording. This discriminator is equipped with two outputs. One feeds the speed control servomechanism which regulates the frequency of the power to the capstan motor. In this way, the low frequency tape speed variations are eliminated or greatly minimized. The other output furnishes a compensation signal to the data channel discriminators which is proportional to the tape speed noise on the data signal but 180 degrees out of phase. Hence, the higher frequency tape speed variations are eliminated or greatly minimized.

In cases where it is further desired to improve noise suppression—noise generated from other causes as well as tape speed variation—the outputs of the discriminators are fed to the recording device through a filter.

Strip chart presentation of the data provides "quick look" information so that the data may be easily edited. The illustrated system can provide a finished time history of the recorded parameters. Most direct-writing recorders are limited to data of 100 cps or less without the use of peaking amplifiers. Usually, if it is desired to obtain a higher frequency response on "quick look" it may be necessary to employ some special techniques or equipment.



VARIATION OF PLAYBACK TECHNIQUE

FREQUENCY response of direct writing recording may be extended by system in which the speed of the tape is reduced to ⅛ of the recording speed. The frequency of the recorded signal fed to the playback head is then only ⅛ of its original value. By multiplying the output frequency of the playback head 8 times, the frequency of the data channels and the reference frequency are restored to their original instantaneous values. The electrical characteristics of a discriminator require that the FM input be within the range of the bandpass of the discriminator and also meet the center frequency requirements of the discriminator. Therefore, the use of the discriminator has been restored for this scheme by the use of the frequency multipliers.

At this point, it is pertinent to recall the definition of FM: The instantaneous frequency of a carrier is varied by an amount which is proportional to the amplitude of the modulating signal and the rate of change of the carrier frequency is porportional to the frequency of the modulating signal. Although multiplication—after the playback head—has restored the original instantaneous value to the frequency, the rate of change of the frequency is still ⅛ of the recorded frequency. Therefore, the writing stylus of the recorder has 8 times as much time to move to a given deflection. Through this scheme the response of the recorder is effectively multiplied by 8.

The multipliers can be omitted if the center frequency of the discriminator is reduced to ⅛ of its original center frequency by means of adjustments. The selection of the method depends on the available equipment and convenience.

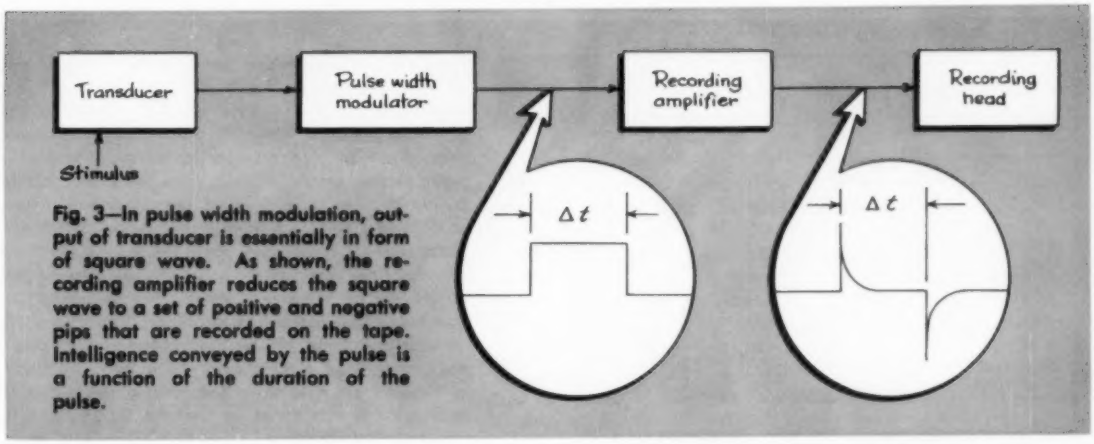


Fig. 3—In pulse width modulation, output of transducer is essentially in form of square wave. As shown, the recording amplifier reduces the square wave to a set of positive and negative pips that are recorded on the tape. Intelligence conveyed by the pulse is a function of the duration of the pulse.

modulated wave becomes that of *Fig. 2b*. Note that the amplitude of the FM carrier is constant and only the frequency of the output wave varies.

Compensation for Tape Speed Variations. It is evident that as the tape is passing over the recording head any variations in tape speed will introduce an error or noise in the recorded FM signal. Low frequency noise components are often called wow and are generally a result of some inadequacy in the mechanical design of the recorder. For example, an eccentricity anywhere in the tape drive system will produce wow. Flutter is a random type of noise and may result from dynamic errors in the tape speed regulating system, and/or tape stretch.

In general there are three different approaches to removing the effects of tape speed noise. First, perfection of design in the recorder is sought. Second, special techniques of recording data are employed which are less susceptible to the effects of flutter. Third, compensation for tape speed noise is used during playback. All manufacturers of magnetic tape data recorders follow all three approaches in varying degrees. For example, constant speed of the capstan drive is a major problem in the design of a portable tape recorder since a steady 60 cycle power source to drive the capstan motor is rarely available. To circumvent this, the power available, usually of 400 cycle origin, is used to generate a suitable constant frequency which is power amplified to drive a hysteresis capstan motor. The associated mechanisms of the tape transport are held to close tolerances during manufacture to eliminate the components of wow and flutter which may be produced by the capstan motor and tape-transport mechanism.

To illustrate another approach, a special technique of recording employs the combined characteristics of suppressed-carrier amplitude modulation and frequency modulation. Initially, the transducer is excited by an ac voltage of fixed frequency. The output of the transducer is a suppressed-carrier amplitude modulated wave which is then used to vary the frequency of an FM oscillator. Because of the double amplitude type of modulation, the oscillator delivers an output which is proportional to the peak-to-peak swings in its frequency rather than to deviations of its center frequency. Since the intelligence contained in the output signal of the FM oscillator is relative in nature, this method of modulation is free from the effects of center frequency drift and is relatively insensitive to any wow and flutter in the tape transport mechanism.

The output of the FM oscillator is multiplexed with the carrier excitation and the composite signal is recorded on one track of the tape. During playback, a filter network separates the two frequencies. After the FM signal is demodulated, it is introduced to a second demodulator which treats the suppressed-carrier amplitude component. The output of the final process is the original data. In cases where the data signal is a direct current, an inverter—using the carrier excitation frequency as a reference—is employed. Thus, the characteristics of suppressed-carrier amplitude modulation are preserved.

A third approach stresses the use of compensation techniques in the playback of the recorded signal. An accurate reference frequency is recorded on one track of the magnetic tape. On playback, the reference frequency is fed to a compensation discriminator which furnishes a signal to a voltage-controlled oscillator. The output of the oscillator provides the frequency of the power source driving the capstan motor of the tape transport. In this way the playback tape speed tends to duplicate the recording speed, minimizing wow and flutter.

To remove the higher frequency components of wow and flutter, since the response of the speed control system is limited to relatively low frequencies, the output of the compensation discriminators is subtracted from the output of the data discriminators. Because the discriminated reference signal is proportional to tape speed noise, output noise of the data discriminator is thus cancelled.

Multiplexing. To realize maximum economy of tape in data recording, a process called multiplexing is frequently used. In an FM system, the continuous reading of several bands of information on one tape track is called *frequency division*

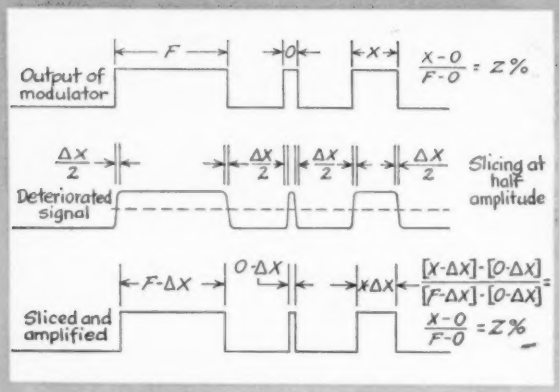


Fig. 4—To counteract data pulse deterioration in PWM/FM system a full scale pulse of width *F* and a zero scale pulse of width 0 can be recorded along with the data pulse of width *X*. For the sake of demonstration, the pips are integrated to show the effects of wave shape deterioration. With the signal in this state, a thin slice is taken out of the waveform at the half amplitude point and then amplified to a sharp rectangular wave. If in every case, the pulses reach full amplitude, then the distortions at the leading edges of all pulses will be similar, or almost so. A similar observation holds true for the distortion at the trailing edges of the pulses. Thus, the amount that the reshaped pulses have narrowed after slicing is the same in each case. In a relative sense, then, the ratio of signals out of the modulator is the same as that on playback after slicing and amplification.

multiplexing. The FM carriers in this process must be of different frequencies separated by an amount such that, under full deviations, no channel frequencies will cross. On playback, the composite signal is separated into individual carriers through the use of band pass filters. In this manner, there is no loss of signal intelligence.

Another form of multiplexing is called *time division multiplexing* or *commutation* which can also be applied to an FM system. With this technique, a number of data channels feed the terminals of a commutator switch. Each channel is then sampled sequentially. Sampling is accompanied by a substantial reduction of frequency response which can be recorded accurately.

Noise Suppression. Noise in a magnetic tape system is produced by a variety of things some of which are cross talk in the recorded track, thermal agitation and microphonics in the electronic equipment, uniformity of the magnetizable layer on the tape, tape granularity, and tape speed variations. Those which affect the amplitude of the recorded track have a pronounced effect on direct recorded signals. Those which affect the frequency of the recorded signal have a pronounced effect on FM recorded signals.

In all systems, a certain amount of noise due to cross talk and system electronics exists, but

GLOSSARY OF TAPE RECORDING AND TELEMETERING TERMS

Accelerometer—A device which transforms acceleration into some other state; e.g., a change of inductance, crystal stress, or resistance.

Attenuation—The reduction of a signal — usually with respect to voltage, current, or field strength.

Audio Oscillator—A controlled variable frequency generator which may cover the spectrum from 0 to approximately 100 kc.

Commutation—A device which provides sequential sampling of a number of functions. It may be electromechanical or electronic.

Cross Talk—Interaction between signals recorded on two or more adjacent tape tracks. This is caused by close head spacing.

Deviation—With regard to FM, it is the variation of the carrier frequency which is produced by the modulating signal.

Discriminator—A system of electronic circuits designed to extract the intelligence from an FM signal. The amplitude of the output voltage is proportional to the frequency excursion of the FM signal.

Discriminator Bandwidth—The total range of frequency components accepted by the discriminator equipment over which the output voltage is directly proportional to the frequency deviation of the input signal.

Filter—A network designed to pass signals within a specified frequency range while attenuating undesired frequencies.

FM/FM—This is the use of the principle of frequency modulation at two points in a system. In an FM/FM telemetering system, the first FM takes place when the subcarrier oscillator is frequency modulated by the transducer intelligence; the second FM occurs when the subcarrier oscillator frequency modulates the radio frequency carrier which is transmitted to a receiving station.

Gate—This is an electronic circuit which is in the category of heavily biased relaxation circuits. It may exist in the form of a multivibrator generating a square wave from triggering pulses. It may act as an electronic switch to control the counting period of a counter.

Multiplexing—Frequency division multiplexing is the mixing of two or more signal frequencies to form a single composite signal frequency for recording on one

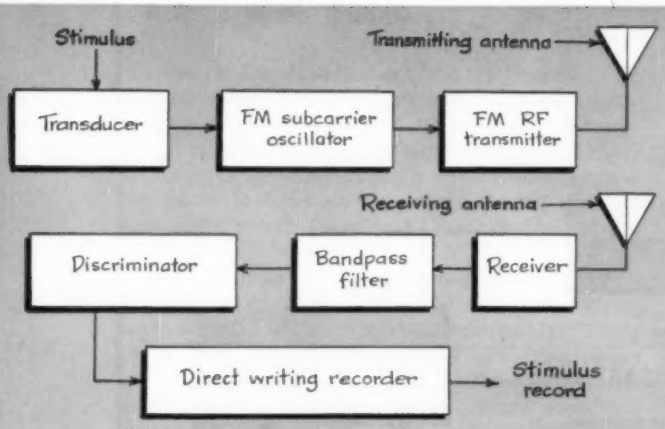


Fig. 5—In FM/FM telemetering system shown, the transducer produces a voltage analog of the stimulus which in turn deviates the frequency of the sub carrier oscillator from its center frequency. The output of the sub carrier oscillator is then a frequency analog of the stimulus and this FM signal then modulates the FM transmitter. In this particular arrangement, one to 18 sub carriers may be used to modulate the transmitter. The radio receiver collects these mixed frequencies which are in turn fed to a series of bandpass filters—separating the individual sub carriers. The FM signals from the filters are converted to voltage analogs by the discriminator which may then be used to drive the recording styli.

the noise is well below the useable levels of the data signals. However, the lack of uniformity of the magnetizable layer and the presence of relatively large granules in the tape will cause wide variations in the level of the signal on playback. FM signals are recorded at constant amplitude and in the process of recording, the output of a limiting amplifier in the FM oscillator is sufficient to drive the tape to saturation on the peak of the waveform. Any loss or variations in amplitude are restored during playback by a second limiting amplifier contained in the data discriminator.

The principal sources of noise in the FM system are wow and flutter which primarily cause a false modulation of the carrier. This is greatly minimized through electronic compensation techniques previously discussed. If it is not desired to extract the full range of frequency response of the FM system, additional noise suppression may be accomplished by limiting the frequency of the demodulated intelligence. For instance, suppose the maximum frequency response of the particular FM system is 5000 cps, however, the maximum desired frequency spectrum of the intelligence is 500 cps. By installing a low pass filter at the output of the data discriminator, all frequency components of noise and signal above 500 cps are sharply attenuated.

tape track or for transmission over a single RF channel. Time division multiplexing is the same as commutation.

Pickup—This is really the element in a transducer which performs the final transformation of the data signal; however, the term is frequently used interchangeably with transducer.

Piezoelectric—The property of certain crystals to create a potential difference between two faces of the crystal when it is subjected to physical distortions.

PWM/FM—This is similar to FM/FM, except that in the first step, the signal from the transducer modulates a pulse generator which produces a pulse of a duration that is proportional to the amplitude of the signal.

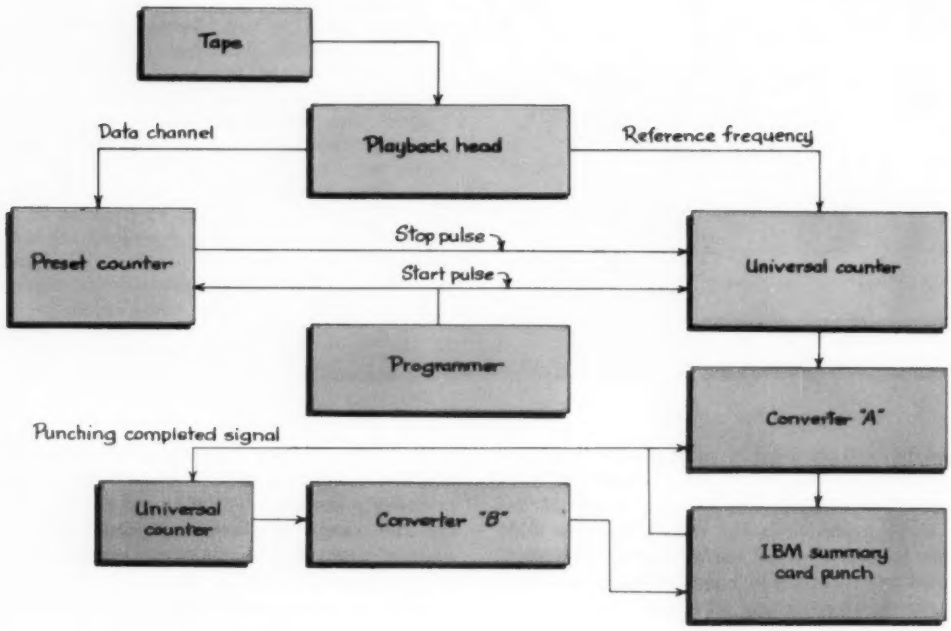
Reference Frequency—A precisely known frequency which is generated by a fixed frequency oscillator of exceptional stability.

Subcarrier Oscillator—An oscillator which transforms the analog output of a transducer to an analog of frequency variations from the oscillator center frequency. In this respect, it is identical to an FM oscillator; however, the carrier frequency of the FM oscillator may be arbitrarily chosen whereas the center frequency of the subcarrier oscillator must conform to Research and Development Board specifications.

Telemetering—The transmission of a signal through an RF link or wire to a distant receiving station where an indicator or recorder measures the quantity that instigated the signal.

Transducer—This is an assembly of components which transforms a stimulus into a usable analog of the stimulus. In doing so, the amount of energy taken from the system under observation must be negligible. For example, consider a strain gage type pressure transducer. Some energy from the system deflects the center point of a diaphragm. Thus an analog of pressure has been created in terms of displacement. The diaphragm is attached to the prestressed leg of a bridge, and the change in deflection is transformed to a change in resistance which is finally transformed to voltage with an applied excitation to the bridge.

Variable Reluctance—This is a principle employed in some transducers. An air gap in the magnetic core material of an indicator is varied. Hence, this controls the magnetic reluctance or resistance to flux as the width of the air gap varies. In this way, the inductance of the coil is varied. If the core is permanently magnetized, an emf is induced by variations of the air gap.



APPLICATION OF FM TECHNIQUES TO DIGITAL PLAYBACK

FREQUENCY modulated intelligence may be converted into digital form with an accuracy that may depend almost entirely upon the accuracy of the data originating transducer.

This system is currently used by several aircraft manufacturers, and the Air Force at Edwards Air Force Base.

The FM data signal of unknown value is counted by a preset counter which is set to count a discrete number of cycles. The universal counter counts the known reference frequency which had been simultaneously recorded on the magnetic tape with the unknown data frequency. Operation of the system is initiated by an electrical pulse from the programmer which simultaneously starts both counters. When the preset counter reaches its set limit, a stop pulse is introduced to the universal counter. This point passes through a special converter and is punched on an IBM card. The card punch feeds a "punching completed" signal to a separate universal counter and converter *A*. The former is to provide a sequential system of identifying the cards, and the latter is to permit converter *A* to accept a new frequency count.

As discussed previously, the major source of error in an FM data system where information is recorded on magnetic tape results from wow and flutter. As noted, however, both reference and data signals had been simultaneously recorded and as a consequence both are subject to the same tape speed variations during recording, and playback as well. The changes in frequency of the playback signals from the data frequency track and the reference frequency track due to these tape speed variations is the same, percentagewise. Thus, with the counter setup described, errors due to tape speed variations are cancelled. A proportionality exists between the two counters which may be expressed as: $A:B = C:D$ where A is the known preset count in cycles, C is the universal count in cycles, and B is the unknown frequency in cps, D is the reference frequency in cps.

The ratios are units of time or, in fact, are identities representing the period of time of the count. Now, let it be supposed that for some given instant in recording that the tape has an average slowdown that causes a 10 per cent increase in the recording of the unknown frequency B and the reference frequency D. The relationship thus becomes $A:1.1B = C:1.1D$. The percentage error obviously cancels.

It is evident that the accuracy of this technique depends mainly on the accuracy of the data-originating transducer. Also, since the method is an averaging one, the longer the count, the finer the accuracy. The counters in the system have an accuracy of plus or minus one event or cycle. Since the reference frequency is usually higher than the data frequency, the latter is selected to control the count of the reference. In this way, the accuracy of the method is optimized.

The speed of digitizing of the system is limited to about 60 data words per minute by the card punching operation. As a consequence, the system shown would be good only for steady state or slowly varying data. The response could possibly be improved by slowing down the tape playback speed and using a shorter period of count or using frequency multipliers and the same period of count. In this way, the frequency response of the data would be extended beyond the limit of the output device, the card punch.

Pulse Width Recording

Pulse width modulation (PWM) recording of data combines some features from both the digital and FM methods. In PWM, the output of a transducer is introduced to a pulse width modulator or keyer. This is essentially a square wave generator which provides an output wave with a period that is a linear function of the applied signal, *Fig.* 3.

The recording amplifier differentiates the incoming square wave pulse which reduces the square wave to a set of positive and negative pips. These are recorded on the tape. On playback, the pips are used to trigger a bistable oscillator which regenerates the square wave. The square wave may then be integrated for voltage analog output, or it may gate a counter for digital output.

Since the intelligence conveyed by a pulse in a PWM system is a function of the width or duration of the pulse, the accuracy of the system is dependent upon the reproducibility of the leading and trailing edges of the pu'se. A method of counteracting deterioration of the leading and trailing edges of the data pulse is by a relative or percentile treatment of the data pulse.[3] This method is normally used in telemetry setups using PWM/FM techniques, but there seems to be no reason why it would not work equally well on PWM intelligence recorded on magnetic tape. The technique is graphically illustrated in *Fig.* 4.

Direct Recording

Direct recording affords the simplest technique and the highest frequency response but also the poorest accuracy. As was pointed out, the upper frequency limit of magnetic tape is about 1500 cycles per inch per second of tape speed. It is common practice in direct recording to introduce a bias signal simultaneous'y with the intelligence signal. The function of the bias signal which is of considerably higher frequency than the data signal is to minimize the effects of hysteresis in the tape. This is analogous to a mechanical vibrator which may be used to overcome instrument friction. During playback, the bias signal is removed by a low pass filter.

Direct recording is subject to errors caused by wow and flutter since compensating equipment dur'ng playback is not fully adaptable to this method of recording. Some low frequency noise components can be removed through control of the playback drive motor. Direct recording would be advantageous only when extremely wide frequency response and large dynamic range is required.

Telemetry

The subject of telemetry is too broad to be considered here in any great detail. It is important, however, that telemetering be defined and explained. The term "telemetering" implies that an electrical signal (current or voltage) is transmitted to a distant station where an indicator or recorder measures the quantity that instigated the signal.[4] Two methods of linking the intelligence source with the receiving station are by means of wire or radio signals.

In order to properly transmit intelligence through a radio frequency link, it must be in such a form that it can be recorded at the receiving station with little or no loss of information and with no distortion to the intelligence. All of the methods of transforming the data signals so far discussed are applicable to frequency modulation of a radio frequency oscillator. For example, the output of the frequency modulated subcarrier or audio oscillator may be used to deviate the frequency of a radio frequency oscillator. This gives rise to the term FM to FM sometimes expressed as FM/FM. A simplified FM/FM system is shown in *Fig.* 5.

The subcarrier oscillator in *Fig.* 5 may be replaced by a commutator and a pulse width modulator. The pulse output of the pulse width modulator then modulates the RF transmitter. With appropriate changes in the receiving equipment the system becomes a PWM/FM system.

The insertion of a pulse amplitude modulator between the transducer and subcarrier oscillator in the illustration converts the system to that of a PAM to FM to FM, expressed as PAM/FM/FM. A pu'se amplitude converter would also have to be inserted between the discriminator and the direct writing recorder.

Two systems of telemetry using amplitude modulation of the radio frequency transmitter are pulse time modulation and pulse code modulation. Symbolically, these are represented as PTM/AM and PCM/AM. Both systems are capable of transmitting a large number of data channels through various techniques of multiplexing.

Telemetry permits monitoring of a test while it is in progress. Usual'y, a tape recorder is connected to the output of the bandpass filter, and data are recorded on one or more tape tracks. Thus, "quick look" editing of the data can be accomplished as the test progresses. Sometimes, the data are also recorded simultaneously with another magnetic tape recorder on the test vehicle, e.g. an aircraft. The recording on magnetic tape at the ground installation serves mainly as an auxiliary device in the event of total loss of the test vehicle.

With the general description of magnetic recording and playback presented in this article to serve as a basis, more specific prob'ems of the application of tape recording can be developed. Instrumentation applications, the theme of the second part of this article, will be covered in a future issue.

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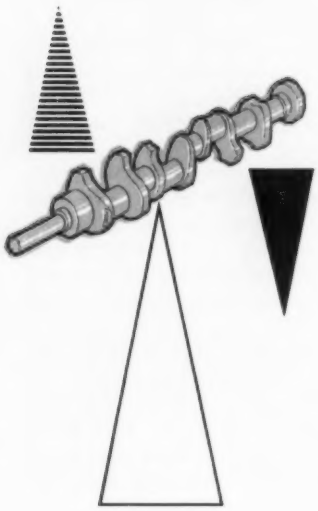


CRANKSHAFT LINE USES

IN-LINE PRODUCTION BALANCING

High speeds of rotation common in many modern devices place increasing emphasis on balancing of rotating elements. The balancing operation described here for crankshafts indicates possibilities in automating such operations.

By **WARREN M. GRUBER,** Head, Electronics Dept., Tinius Olsen Testing Machine Co., Willow Grove, Pa.

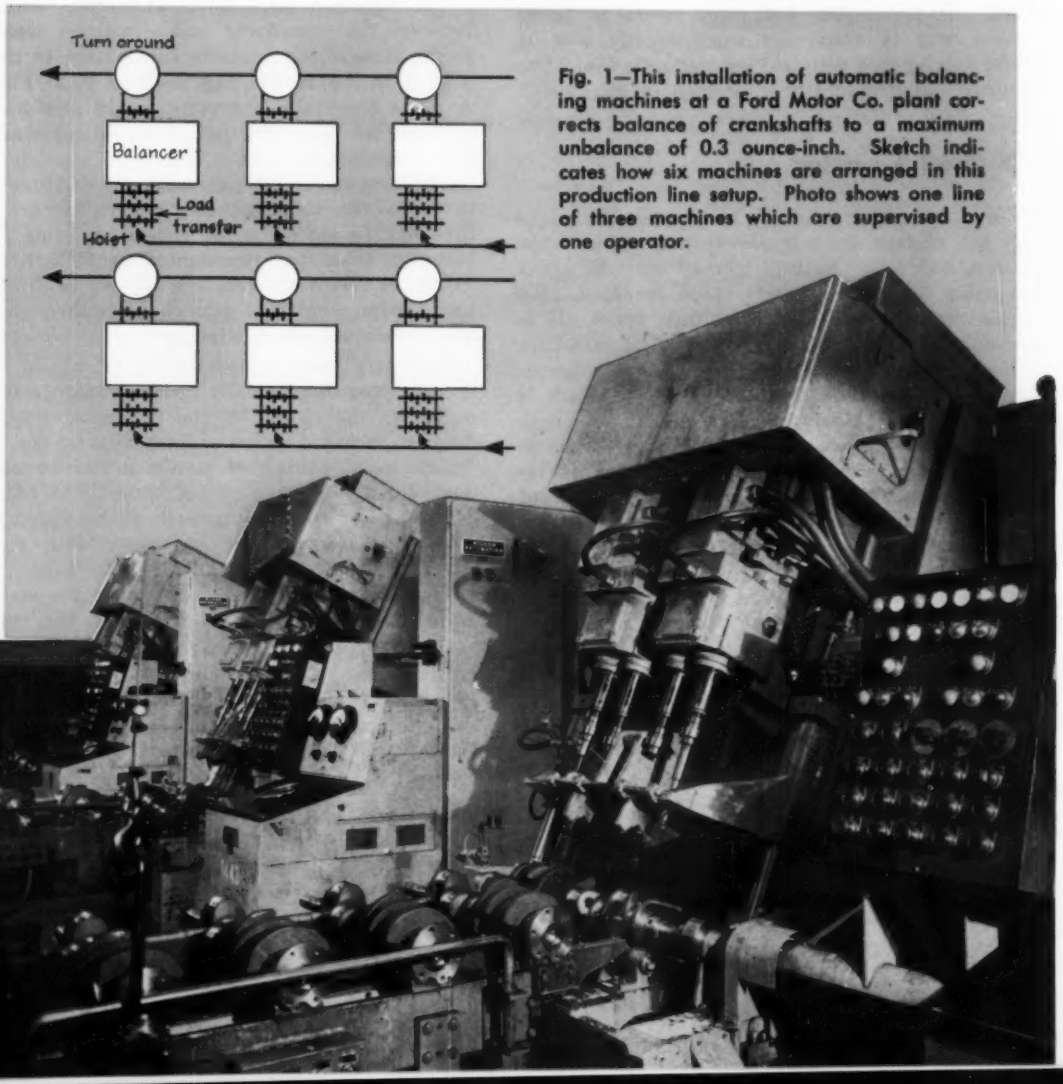


Fig. 1—This installation of automatic balancing machines at a Ford Motor Co. plant corrects balance of crankshafts to a maximum unbalance of 0.3 ounce-inch. Sketch indicates how six machines are arranged in this production line setup. Photo shows one line of three machines which are supervised by one operator.

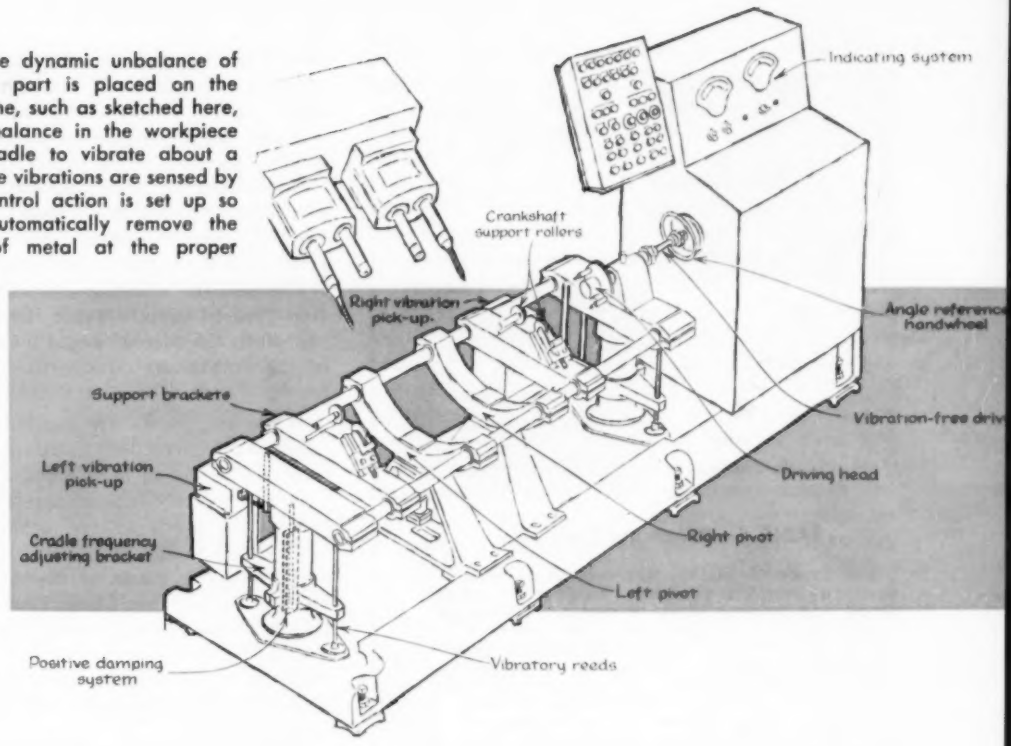


Fig. 2—To measure dynamic unbalance of a crankshaft, the part is placed on the cradle of a machine, such as sketched here, and rotated. Unbalance in the workpiece will cause the cradle to vibrate about a locked pivot. These vibrations are sensed by a pickup, and control action is set up so that drills will automatically remove the proper amount of metal at the proper point to achieve suitable dynamic balance.

DEMANDS for ever higher rotational speeds coupled with volume production requirements have spurred the development of balancing machines which have been progressively more accurate, faster, and easier to operate. In increasing measure, the factor of human error, as well as guesswork, is being removed from balancing. The cost per unit to balance rotors, flywheels, armatures, crankshafts, etc., has been steadily reduced.

Accurate balancing of automotive crankshafts to within fractional ounce-inch tolerances on a production basis was considered all but impossible a few years ago. Today, it is being accomplished in a number of automobile plants using completely automatic balancing machines, *Fig.* 1, developed and manufactured by the Tinius Olsen Testing Machine Co. Up to 30 crankshafts per hour per machine are checked for unbalance and corrected to within 0.3 ounce-inch on a production line basis. Since the operation is conducted automatically following a preset cycle, the possibility of human error or misoperation is eliminated. All crankshafts must fall within established tolerances before they are transferred from the machine to the assembly line.

Appearance of a part is no proof of proper balance, TABLE 1. Even an element machined to the closest tolerance may be unbalanced, resulting in excessive vibration even at normal operating speeds. This unbalance may be caused by imperfection in the material of the part, variations in the distribution of weight, nonuniform impregnation or coating, as well as errors in design.

When a crankshaft is suspended in bearings and rotated, its axis of rotation is established by its journal axis. If the crankshaft is not dynamically balanced about the journal axis, the bearings must exert forces to keep it rotating about that axis. These forces are proportional to the amount of unbalance and the square of the rotational speed. In an automobile traveling 50 mph the crankshaft may turn at approximately 3000 rpm. Ten ounce-inches of unbalance, common for crankshafts prior to balancing, at this speed would mean 160 pounds of force being exerted on the bearings due to that unbalance. The bearing load due to unbalance forces may, therefore, greatly exceed the static load in modern high speed engines. Such unbalance results in excessive noise, wear on bearings, increased oil consumption, decrease in effective power, and increased maintenance.

Although great care is taken to design a crankshaft so the mass is symmetrically distributed about the axis of rotation, it is not practicable to maintain the production tolerances that would be required to eliminate balancing operations. In the past, determining the amount and angular location of unbalance and correcting the condition called for the trial and error use of several machines and highly skilled labor. However, today several engine plants are keeping up with the high speed production of parts by using electronically controlled automated balancing machines.

Balancer Operation

In one of its engine plants, the Ford Motor Co. uses a battery of six automatic testing and correcting machines. Each of these machines uses a pivoted cradle, *Fig.* 2, to support the crankshaft being rotated and checked for unbalance. Rota-

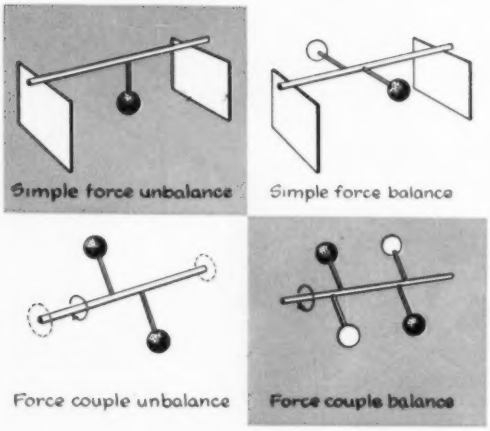


TABLE 1—Balancing Principles

Two types of balance are considered with regard to rotating elements: balance of simple forces and balance of force couples. Balance of simple forces is obtained when the mass of the part is distributed in a balanced manner around the axis of rotation without regard to its distribution along that axis. In other words, when the center of gravity of the part is on the axis of rotation, simple forces are in balance in the part; if it is placed on a pair of knife edges so that it could roll about the axis of rotation, it will be in equilibrium in any position. If a part in which simple forces are not in balance is placed on knife edges, it will roll until the heavier portion is down.

The amount of unbalance is expressed as a weight times the distance of that weight from the axis of rotation. For example, an unbalanced weight of ½ ounce located 2 inches from the axis of rotation is expressed as an unbalance of 1 ounce-inch. To correct simple force unbalance, an equivalent amount of material can be removed at the angular location of the unbalance around the rotation axis, or an equivalent weight can be added to the opposite side of the part. Simple force unbalance requires only one point of correction, and that point can be anywhere along the axis of rotation just so it is at the proper angular location around the axis.

Balance of force couples occurs in a rotating body when its mass is properly distributed along the axis of rotation as well as around it. When the mass of a rotating body is not properly distributed along the axis of rotation, the centrifugal forces created by the unbalanced masses produce a force couple rotating with the body and tending to displace the ends of the body in opposite directions. The amount of force couple unbalance is expressed in terms of ounce-inches for each of two planes located some distance apart and perpendicular to the axis of rotation. The location of these planes is arbitrary, but a correction in each of two such planes is sufficient to establish force couple balance. The measurement and correction planes do not have to coincide with planes in which the causes of unbalance occur since a force couple has the same moment no matter where it is applied along the axis of rotation. Only simple force balance can be obtained by a static balancing process since the workpiece is not rotated. Simple force balance and force couple balance can be obtained by a dynamic balancing process since the workpiece is rotated. As commonly used, the term "statically balanced" impiles that simple forces are balanced in a part; the term "dynamically balanced" implies that both simple forces and force couples are balanced.

tion is provided by a positive speed motor which turns a driving head through a universal joint drive. Holes in the flange of the crankshaft are engaged by drive pins on the driving head. The cradle has two pivots whose positions determine the locations of the measuring planes. For crankshafts these planes are chosen to fall in the number 1 and 8 counterweights. When the pivot for one plane is locked, the other pivot is unlocked. The cradle and the rotating crankshaft it supports are thus free to vibrate about the locked pivot in response to the forces caused by unbalance in planes of the crankshaft outside the plane of the locked pivot.

When the pivots are located in the two planes selected for correction, unbalance readings taken in either plane as to both amount and angular location, are entirely independent of readings taken or corrections made in the other correction plane. This is due to the fact that any unbalance or correction in the plane of the locked pivot has no moment, about that plane, hence cannot affect the balance condition measured with that pivot locked. When the left pivot is locked the amplitude of vibration of the cradle is proportional to the amount unbalance effective in the right correction plane.

These vibrations are sensed by a pickup, a separate pickup being used for each pivot. The pickup is a velocity-type vibration unit in which a movable coil in the field of a stationary permanent magnet receives the same motion as the cradle and generates an ac signal. The maximum amplitude of this ac voltage is proportional to the amount of unbalance and occurs when the unbalance is in a known position with respect to the cradle. Another signal generator connected to the spindle driving the crankshaft supplies a signal pulse when the crankshaft is in a known position with respect to the cradle. Comparison of these two signals indicates the angular location of the unbalance.

Basically, the Electrodyne measurement circuit for this machine is a two-channel arrangement having an amount channel and an angle channel. In the amount channel, the signal from the vibration pickup is amplified and fed to a voltmeter which senses the amplitude. This accurate indication of the amount of unbalance can be translated directly into ounce-inches.

Simultaneously, the angle channel forms the same signal into a pulse, and determines the phase displacement between this pulse and the reference pulse generated on the machine spindle. To obtain the angle reading, the sine wave signal from the vibration pickup is first passed through wave shaping circuits to form it into a square wave. It is passed through a differentiating circuit to convert it to a sharp pulse occuring at the leading edge of the square wave. This is one of two pulses fed into an electronic phasemeter. The second pulse comes from the reference pulse generator located on the spindle of the machine. The electronic phasemeter determines the phase difference between these two pulses. This is an accurate indication of the angular location of the unbalance in that

plane of correction. An electronic relay circuit is used in the phasemeter to determine the time interval between the pulses.

Production Sequence

An automatic walking beam type of loader developed by Wilson Automation feeds each crankshaft, in turn, into the machine. This unit is controlled by solenoid operated hydraulic valves, which cause the beam to raise, advance one position, lower, and return. In the balancing and correcting station, the crankshaft is placed on rollers mounted on the balancing machine cradle. The driving holes in the flange of the crankshaft are engaged by spring-loaded, air retracted drive pins on the driving head. The driving head is rotated by a jogging motor until the pins engage; then, the main balancing machine motor is energized.

As soon as the crankshaft reaches full balancing speed, the angle and amount of unbalance for each of the two planes of correction (right and left) are separately determined by the Electodyne system. The amount and angle indications are stored in a memory unit in the machine. Readings are also shown on two meters, but readings or manipulations by the operator are not required when the machine is being run automatically.

When the readings have been taken, the drive motor is braked to a stop and an angle servo positions the crankshaft to bring the "heavy" portion beneath the drill in one correction plane. The crankshaft is clamped in position and a drilling unit supplied by John S. Barnes Corp. is used to remove needed amounts of metal to correct the unbalance, *Fig.* 3. The drilling unit drives the drill to required depths determined by a depth servomechanism controlled by the amount channel of the Electrodyne system. Safety devices prevent overtravel of the drill. After correction is made in one plane, the crankshaft is repositioned for correction in the second plane by a second drilling unit. The crankshaft is then checked for balance before being removed automatically from the machine.

In normal operation, from the loading of one crankshaft to the loading of the next one consumes approximately 1 minute and 57 seconds. The automatic features eliminate the factor of human error in determining final balance; as a result, modern engines with accurately balanced crankshafts run smoothly at higher speeds. Only one man is normally required to supervise three of these automatic balancing machines.

There are many cases when the unbalance in one plane exceeds the eight ounce-inches that can normally be corrected by a single hole. In such instances, the automatic positioner indexes the crankshaft for two equal holes to correct the unbalance. Crankshafts are so designed that any unbalance can normally be corrected by drilling or removing weight from the number 1 and 8 counterweights. However, if the unbalance falls outside the amount of correction allowed in these counterweights, the machine goes into a standby condition, signalling the operator that manual correction is required. As an emergency measure this is accomplished by drilling in one of the interior counterweights to bring the unbalance back into the area of correction. This done, the entire automatic balancing cycle is repeated.

This Olsen automatic balancing machine is equipped with safety interlocks which prevent damage to either the crankshaft, machine, or operator in the event of malfunctioning of any part. Should either end or both ends of the crankshaft be within the accepted ounce-inch tolerance, that portion of the correction cycle is automatically bypassed. However, the crankshaft is not removed until it is rechecked and found to be within tolerance. The machine is also equipped with an automatic lubrication system to insure proper lubrication.

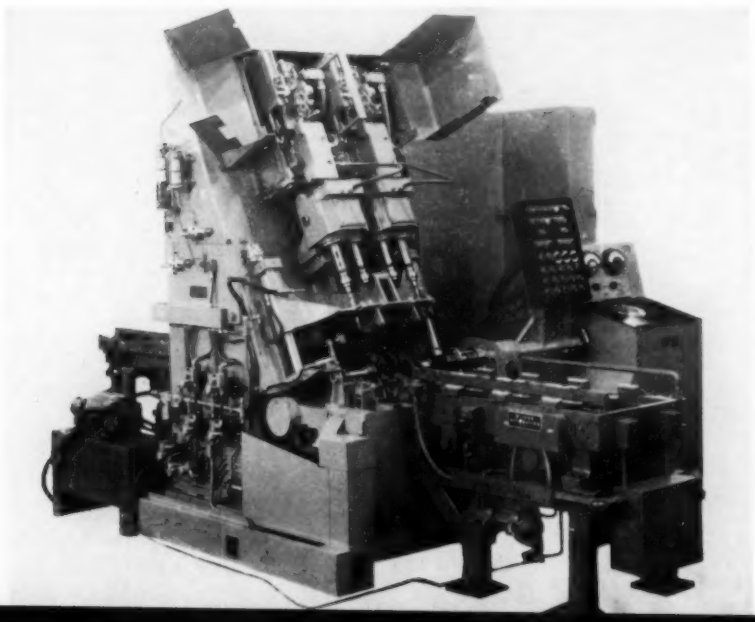
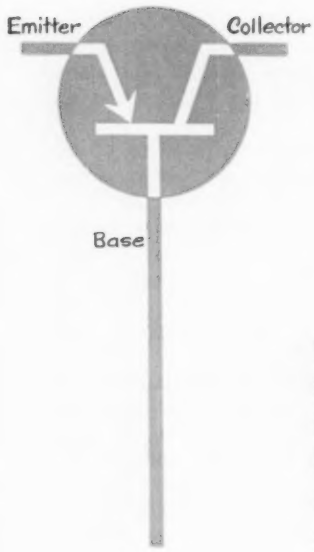


Fig. 3—Photo of one of the machines for Ford, shows covers opened on the drill-feeding servomechanisms. John S. Barnes Corp. supplied the drilling units. Crankshafts are automatically moved into and out of the balancing station by handling equipment furnished by Wilson Automation.



APPLYING TRANSISTORS

• AMPLIFYING • SWITCHING • TIMING
• SIGNAL CONVERSION • AVERAGING

Inherent ruggedness, long life, and high reliability are among the properties of transistors that qualify them for industrial use in automatic control devices. In addition, their compactness and low power consumption make them a frequent choice for special applications. Here the author describes several successful applications of transistors in industry.

By **JAMES R. WALKER**, Director of Research, Gemco Electric Co., Detroit, Mich.

AUTOMATIC CONTROL of machine members used in manufacturing processes may be accomplished through use of power conversion devices that are responsive to both command and process feedback data. However, the power level of the electrical signals available from the usual positional or thermal data repeat-back devices used to actuate such power conversion means lies in the range 10^{-4} to 10^{-14} watts. For successful utilization then, it is necessary that the signals from the repeat-back devices be amplified.

In order that the magnitude of amplification required between typical signal elements and power conversion devices can be appreciated, TABLES 1 and 2 have been prepared. TABLE 1 shows average signal output levels of some process data pickoff devices, and TABLE 2 outlines average input power levels required by several common power conversion means. Consideration of this data reveals that the only power conversion devices included in TABLE 2 that are capable of operating directly from some of the signal devices listed in TABLE 1,

TABLE 1—Characteristics of Some Common Signal Devices for Machine Control

Device	Disturbance	Output Impedance	Output Power, watts	Electrical Recovery Time
Barium titanate	1 psi	0.17 meg.	3.6×10^{-7}	.....
Linear differential transformer	0.001 inch	500 ohm	8×10^{-9}	less than 1 cycle of carrier
10-turn potentiometer	1 angular degree	2500 ohm	3.6×10^{-7}	negligible
Resistance bulb	1 degree C	250 ohm	2.6×10^{-12}	0.6 sec.
Rochelle salt	1 psi	5.1 meg.	1.7×10^{-7}	.....
Silicon diode voltage reference	0.1 volt	500 ohm	2×10^{-4}	negligible
Strain gage	1 psi	120 ohm	1.1×10^{-13}	negligible
Synchro	1 angular degree	1500 ohm	5.6×10^{-8}	less than 1 cycle of carrier
Tachometer generator	1 rpm	500 ohm	2×10^{-4}	0.03 sec.
Thermistor bridge	1 degree C	200 ohm	2×10^{-4}	1.1 sec.
Thermocouple	1 degree C	5 ohm	5×10^{-10}	1.7 sec.
U-frame magnetic pickoff	0.031 inch	100 ohm	6.3×10^{-4}	1 cycle of carrier

TABLE 2—Properties of Some Power Conversion Devices for Machine Control

Device	Input Impedance	Input Power	Output Power	Response Time, sec.	Auxiliary Equipment
Amplidyne generator	2000 ohm	0.05 w.	350 w.	0.06	Driving motor
Hydraulic force motor-valve	1500 ohm	96×10^{-3} w.	5 hp.	0.01	Motor driven pump
Magnetic amplifier switching pair	200 ohm	1.6×10^{-3} w.	500 w.	0.09	None
Magnetic clutch	100 ohm	0.25 w.	200 w.	0.04	Driving motor
Thyratron switching pair	250 ohm	7×10^{-3} w.	1500 w.	10^{-3}	Transformers and phase shifter
Transistor switching pair	110 ohm	1.1×10^{-4} w.	80 w.	10^{-4}	dc power supply and transformers
Vacuum tube triode switching pair	0.2 meg.	2×10^{-3} w.	20 w.	negligible	dc power supply and transformers
Ward-Leonard generator	500 ohm	31.25 w.	1000 w.	0.15	Driving motor

without intermediate amplification, are the thyratron, transistor, vacuum tube, and magnetic amplifier switching circuits.

Ultimate choice of an amplification means for a particular process control system will of course be determined by such factors as the environment in which the system is to operate, reliability, electrical response needed, and space and weight considerations. Field experience with the power conversion devices of TABLE 2, used in conjunction with various control elements under a variety of operating conditions, indicates the desirability of using static power conversion means, excluding vacuum tubes. Consideration will therefore be given to the use of magnetic amplifiers and transistors as power amplification or switching means for use in process control systems. Since earlier literature has been concerned with various types of magnetic amplifier control circuits (see AUTOMATION, Nov., 1956 through April, 1957), it is the purpose of this article to consider some practical applications of transistors in power amplification, switching and control circuits.

▶ Amplifying

Although transistors are essentially small signal devices and as such can amplify only millivolt signals without distortion, it is nevertheless true that they may be employed usefully in control means wherein signals are greater than millivolt magnitude. Because of their inherent signal limiter action, transistor amplifiers will introduce distortion in the output variable for large values of input signal. However, such a condition is not objectionable in a servo amplifier, for example, since saturation output is usually obtained anyway when the error signal into the amplifier is large. Accordingly, certain applications involving

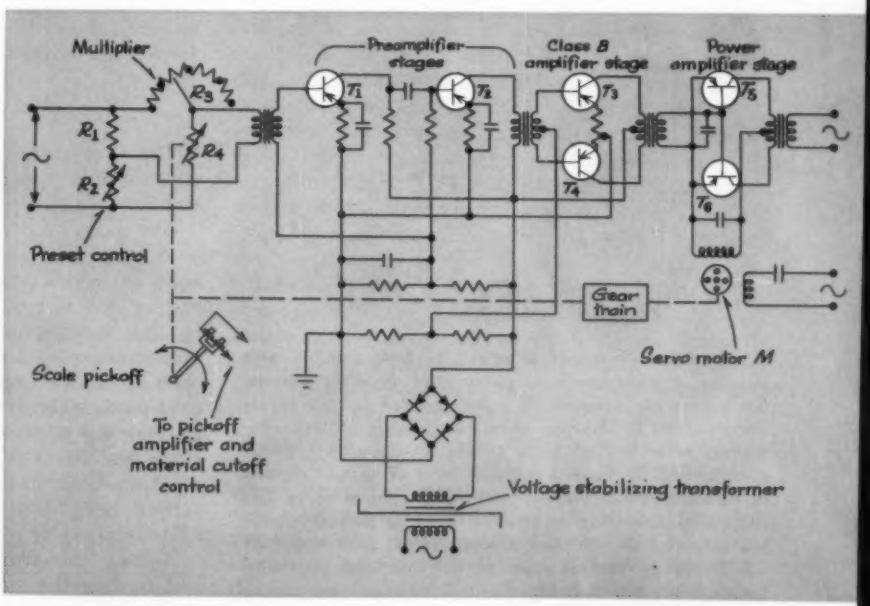


Fig. 1—Application of transistors in a linear control amplifier for a process batching multiplier used with a scale weigh-out control. Error signal from bridge circuit R_1, R_2, R_3, and R_4, is amplified and used to actuate servomotor M. This motor repositions R_4 to balance the bridge and simultaneously positions scale pickoff. When scale pointer overtakes pickoff, material cutoff control operates to stop the flow of material. Accuracy is within ¼ degree of scale indicator angle.

instrument servos (less than 10 watts total motor power input) have been made using transistor amplifiers. These amplifiers have the advantage of increased component reliability and thus reduced maintenance over that normally required with vacuum tube amplifiers.

A circuit for a transistor linear control amplifier is shown in *Fig.* 1. This amplifier was designed for a process batching multiplier used in conjunction with a scale weigh-out control. It may be noted from the diagram that a preamplifier including transistors T_1 and T_2 amplifies the error signal from a resistance bridge composed of fixed member R_1 and variable members R_2, R_3, and R_4. The error signal is then further amplified by Class *B* amplifiers T_3 and T_4, whose higher power level output is then used to proportionally control power transistors T_5 and T_6. The amplitude and phase-varying fundamental frequency component of half-wave current flowing through the capacitor tuned control phase of servo *M* determines the magnitude and direction of torque developed by *M* which in turn repositions bridge resistance R_4 to balance the multiplier bridge. Servo *M* also positions a scale pickoff (switch or magnetic type), and the scale can be caused to actuate a cutoff control when its pointer has overtaken the position of the magnetic or switch pickoff.

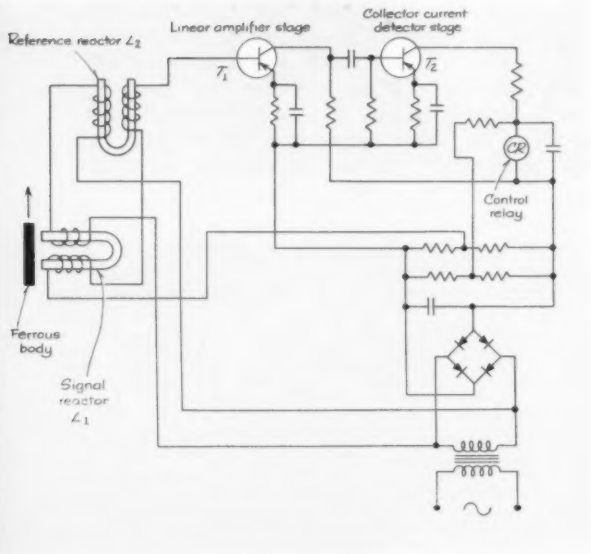


Fig. 2—Position pickoff or proximity limit switch circuit employs transistors in amplifier and detector stages. Secondary ac voltages in signal reactor L_1 and reference reactor L_2 balance when no object is present. Introduction of ferrous body causes an unbalance which is amplified by T_1 and appears as a dc output current in collector circuit of T_2, energizing control relay *CR*. Repetitive actuation is possible with a pickup-to-part spacing of 0.5 inch and a longitudinal part travel of 0.015 inch. Another type of transistorized proximity switch is described in *Fig.* 5.

Positioning accuracies achieved with this system are within ¼ degree of scale indicator angle. Influence of supply voltage changes on the positioning accuracy and response of this amplifier is negligible because a voltage stabilizing transformer is employed in the dc supply system.

Linear transistor amplifiers are also used with a gaging fixture in which the element to be gaged is placed on the fixture and automatically traversed by an inspection head to determine the total peak-to-peak variation in the surface tested. Two separate error synchros are connected to a gaging synchro that is actuated by a roller contacting the specimen. Output of each error synchro

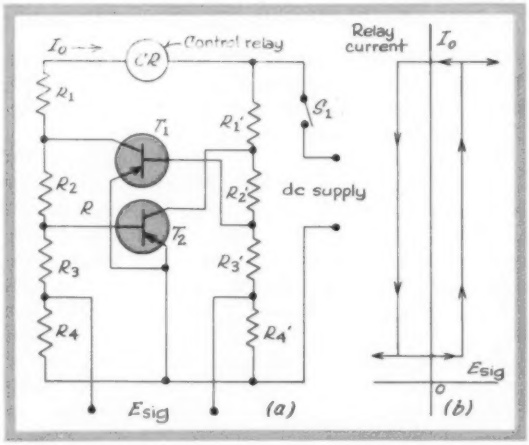


Fig. 3—Transistor binary pair circuit (*a*) is used in counting systems and as a bi-stable switch. Normally transistor T_1 is nonconducting, T_2 is conducting, and relay *CR* is de-energized. When signal voltage is applied, T_1 conducts, T_2 is cut off, and relay *CR* becomes energized. Control characteristic curve (*b*) shows that removal of signal voltage E_{sig} does not affect relay current I_0 once relay is energized. De-energization may be accomplished by opening S_1 or by introducing a reversed-polarity signal.

is fed to a separate servo system which includes a transistor amplifier, magnetic amplifier, and servomotor.

One mode of operation involves a zero or reference position reset for any position of the gage head in which the actuating roller is just contacting the test surface. Once the test surface is in the starting position for gaging, directional biases are placed on the magnetic amplifiers in each of the two servo systems so that one servomotor can only move in a clockwise sense from its starting position, and the other in a counterclockwise direction. Final positions of the error synchros controlled by the two servomotors then reflect peak deflections of the gaging synchro as determined by roller rise and fall.

Adding the two synchro voltages electrically and feeding the sum voltage to a bridge rectifier

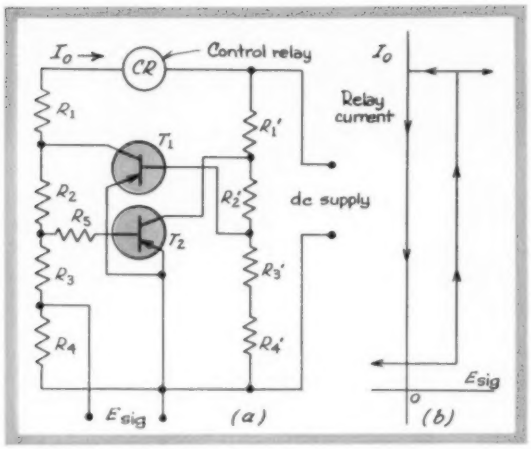


Fig. 4—Circuit shown at (*a*) is a modified version of bi-stable switch of *Fig.* 3. Action is monostable because of weak back-coupling of binary side containing transistor T_1. Control characteristic curve (*b*) shows that relay current I_0 is sustained only when signal voltage E_{sig} is present and greater than zero. Circuits of this type may be used for chatterless operation of control relays from proportionally increasing or decreasing control signals generated by position pickoff devices.

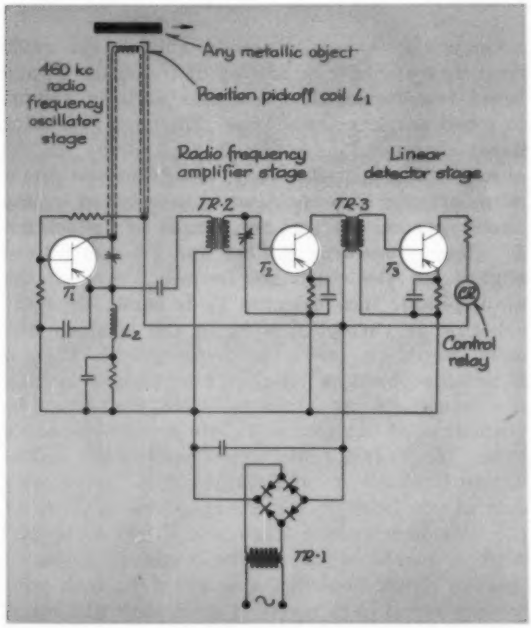


Fig. 5—Position pickoff or proximity limit switch employs radio frequency oscillator stage including transistor T_1 and pickoff coil L_1. Transformers *TR*-2 and *TR*-3 in radio frequency amplifier stage T_2 are tuned to a frequency slightly off that of the oscillator stage, so that input to detector T_3 is small and the control relay is de-energized. When a metallic object is brought into the field of L_1 the inductance of this coil changes sufficiently to bring the oscillator frequency into coincidence with the frequency for maximum amplifier gain. Resulting greater input to detector increases its collector current and control relay becomes energized. This device will operate on an object-to-pickoff spacing of ⅝ inch and a longitudinal part travel of 0.030 inch. All circuit components can be included in a small package.

produces a dc voltage that is an analog of the peak-to-peak displacement in the surface over its test region. By the simple addition of a calibrator circuit this gaging means can be caused to indicate a signal at any preset displacement value in the range 0.001 to 0.1 inch.

Another application of a linear transistor amplifier involves its use in a position pickoff or proximity limit switch as in the circuit of *Fig.* 2. Study of this circuit reveals the use of a two-stage transistor amplifier in which the first stage, T_1, acts as a linear amplifier and the second, T_2, as a collector current detector. The dc collector current in transistor T_2 is almost linearly proportional to the ac signal appearing between its base and emitter.

Circuit function proceeds on the initial assumption of a balanced secondary voltage existing between signal reactor L_1, and reference reactor L_2. This balance may be disturbed by reducing the magnetic circuit reluctance of L_1, as by introducing a ferrous body. Then, the ac voltage amplitude present at the base of transistor T_1 will be inversely proportional to the spacing between the pole tips of L_1 and the ferrous body. If this spacing changes linearly with time, the reactor voltage will change much more rapidly (a hyperbolic function), and as a result the rise in amplified output at the base of T_2 will be step-like in its change with time. Accordingly, the rise in dc output current which energizes the control relay will also be step-like under the influence of small proportional changes in air gap spacing between L_1 and the ferrous body. Repetitive actuation of the control relay can be attained with pickup-to-part spacing of 0.5 inch and longitudinal part travel of 0.015 inch.

▶ Switching

Certain circuit switching functions such as relay action, ac generation, and function generation can be accomplished with transistor circuits similar to those employing vacuum tubes. In most cases the same circuits may be utilized and it is merely a matter of reducing the control and load mesh impedances to correspond with the lower internal impedances of the transistor emitter-base and emitter-collector circuits.

An example of such a circuit, which may be used in a counting system or as a switch, is the transistor binary pair shown in *Fig.* 3(*a*). This employs a basic Eccles-Jordan bistable circuit. Action occurs in this circuit following the assumption of zero signal voltage and closure of switch S_1. Under this condition, output current I_0 is nearly zero in the left branch, thus transistor T_1 is cut off and the collector current in T_2 is at its saturation value. As switch S_1 is opened and closed a great number of times, it is always the case that T_2 is conducting and T_1 nonconducting. This has been made possible by a proper choice of current gain factor for the two transistors. Here the current gain of T_1 exceeds that of T_2; hence

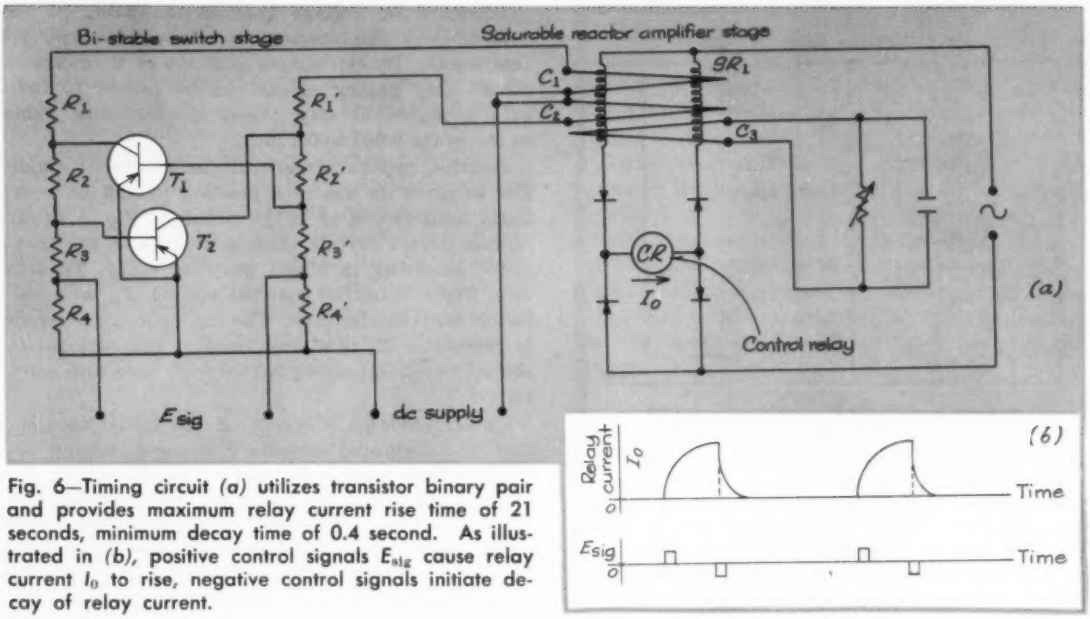


Fig. 6—Timing circuit (*a*) utilizes transistor binary pair and provides maximum relay current rise time of 21 seconds, minimum decay time of 0.4 second. As illustrated in (*b*), positive control signals E_{sig} cause relay current I_0 to rise, negative control signals initiate decay of relay current.

T_1 is rendered nonconductive on a smaller initial transient signal arising from closure of S_1 than is T_2. Due to this action, relay *CR* is de-energized until a control signal is introduced which causes the upper terminal of R_4 to become positive. As a result, T_1 now becomes conductive according to the current locus of *Fig.* 3(*b*), and relay *CR* becomes energized. As may be appreciated from *Fig.* 3(*b*), the withdrawal of control signal to zero value does not reduce the T_1 output current level.

There are now available two means for de-energizing *CR;* either by introducing a reversed-polarity control signal, or by interrupting one dc supply lead through switch S_1. In either case, T_1 will be placed in a nonconductive condition and the control relay will be de-energized.

A modification of this circuit is shown in *Fig.* 4(*a*). Here it may be noted that a monostable action prevails due to weak back-coupling of the normally conductive binary side containing transistor T_1. Thus it is seen from a study of the control characteristic, *Fig.* 4(*b*), that the relay *CR* is energized only when the control voltage E_{sig} is greater than zero.

A circuit of this type may be used to switch a relay or other nonconductive device, without chatter, from a proportionally increasing or decreasing control signal. For example, position pickoff devices such as linear or "E" type transformers, normally proportional in action, may by means of this circuit, be used to cause switching of a control relay.

Another circuit, utilizing the switching capability of transistors, is shown in *Fig.* 5. Such a circuit is useful as a position pickoff or proximity limit switch. Study will indicate a transistor, T_1, used as a radio frequency oscillator for generation of exciting current in a position pickoff coil L_1. It may also be noted that a single-stage radio frequency amplifier consisting of transistor T_2 and tuned transformer *TR*-2 supplies exciting voltage to tuned coupling transformer *TR*-3 and transistor linear detector T_3. Action is as follows: In the absence of a metallic body, the transistor oscillator is tuned to a frequency *f* determined by the circuit parameters and magnitude of inductance L_1. Since transformers *TR*-2 and *TR*-3 are tuned slightly off the resonance frequency *f*, then the ac amplitude into detector T_3 is small, thus the collector dc current flowing in *CR* is small and as a result the relay is de-energized. If now a metallic object is brought near pickoff coil L_1, its inductance will change, thus changing the frequency of oscillator T_1 to an on-resonance value for transformers *TR*-2 and *TR*-3. Consequently, the average value of collector current in transistor T_3 increases and energizes relay *CR*. An on-resonance frequency of 460 *kc* is used with a model of this circuit and it is noted that an object-to-pickoff spacing of $\frac{5}{8}$ inch with a longitudinal part travel of 0.030-inch will result in the described relay action. One advantage in the use of this circuit over its vacuum tube counterpart is the possibility of including all circuit components in a small package with the inductive pickoff coil and thus minimize space requirements.

▶ Timing

An example of the use of a transistor binary pair in a timing circuit is shown in *Fig.* 6(*a*). In the normal output current condition of saturable reactor amplifier *SR*-1, a bias current exists in control coil C_2 due to conduction of T_2 when the supply is first connected to the binary pair in

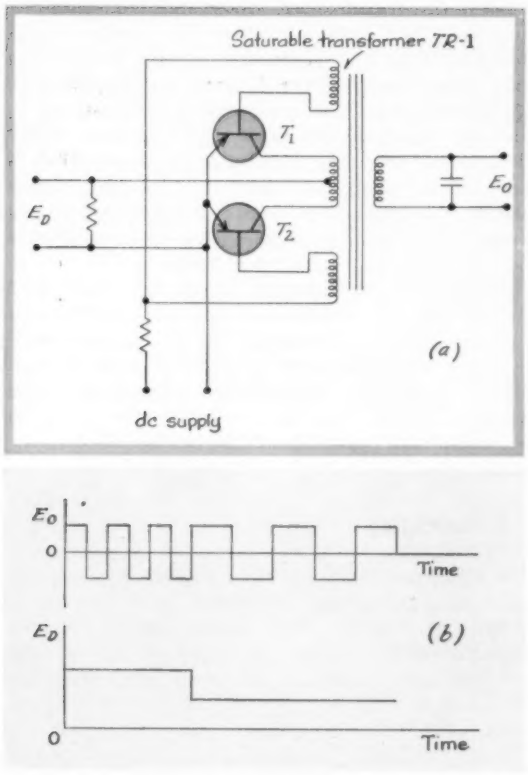


Fig. 7—Transistor-saturable transformer circuit (a) generates square wave output, E_0, frequency proportional to magnitude of dc input signal, E_D, as shown in (b). Device can accept signal voltages developed by thermal sensors, and may be used to operate a temperature indicator.

the absence of a control signal. This bias current produces a reverse flux in the cores of *SR*-1 which reduces its output essentially to zero.

As a positive signal is placed between the top of resistances R_4 and R_4', the conduction of T_2 will cease and T_1 will then conduct. This results in a positive increase of the flux in the cores of *SR*-1, which causes output current I_0 to increase at a rate determined by the ac current amplitude in secondary mesh C_3. Application of a negative signal causes I_0 to decay. Such action is shown graphically in *Fig.* 6(*b*), both for rising and falling conditions of I_0. A current maximum rise time of 21 seconds and a minimum decay time of 0.4 second are attainable.

▶ Signal Conversion

Many linear amplifier circuits normally employing vacuum tubes may be quite simply converted for using transistors, with the advantages of size reduction and increased reliability. Also, certain properties of transistor-magnetic amplifier combination circuits are unique and offer a type of circuit function which is useful in many instrumentation systems. Among the latter circuits is one used to convert dc thermal sensor data to potentials whose frequency is proportional to the magnitude of dc potential, and which may be suitably amplified by a stable ac amplifier.

An example of such a circuit is shown in *Fig.* 7. This circuit depends for its operation on the use of a squarely-saturable magnetic material in transformer *TR*-1 and the fact that alternate conduction of transistors T_1 and T_2 result in a swing of

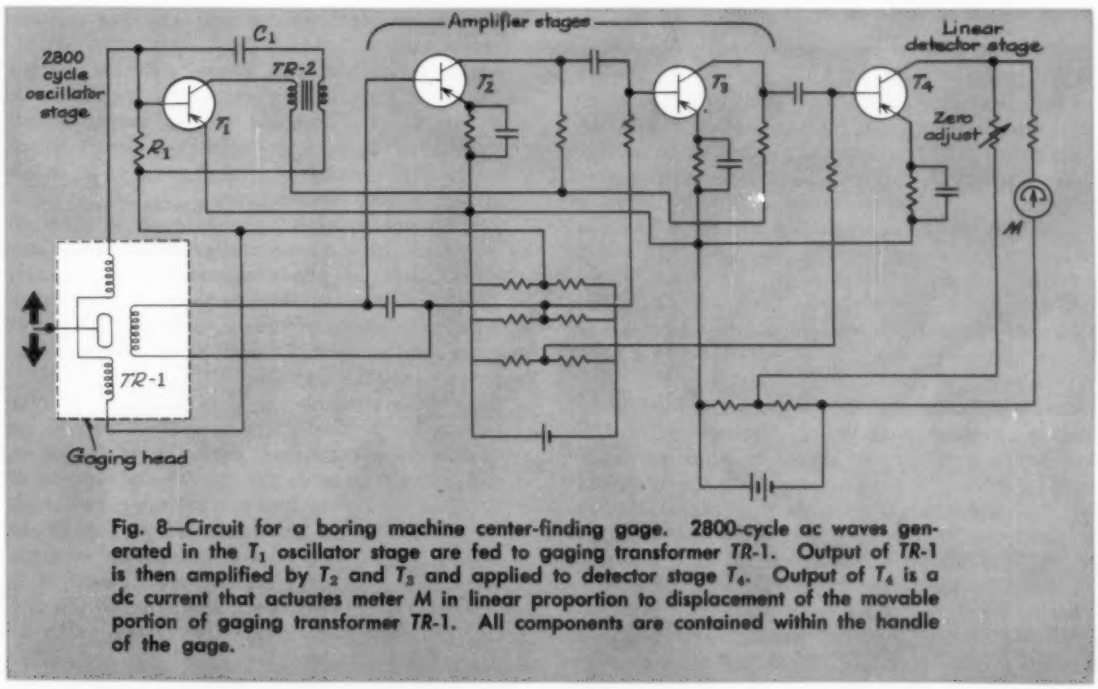


Fig. 8—Circuit for a boring machine center-finding gage. 2800-cycle ac waves generated in the T_1 oscillator stage are fed to gaging transformer *TR*-1. Output of *TR*-1 is then amplified by T_2 and T_3 and applied to detector stage T_4. Output of T_4 is a dc current that actuates meter M in linear proportion to displacement of the movable portion of gaging transformer *TR*-1. All components are contained within the handle of the gage.

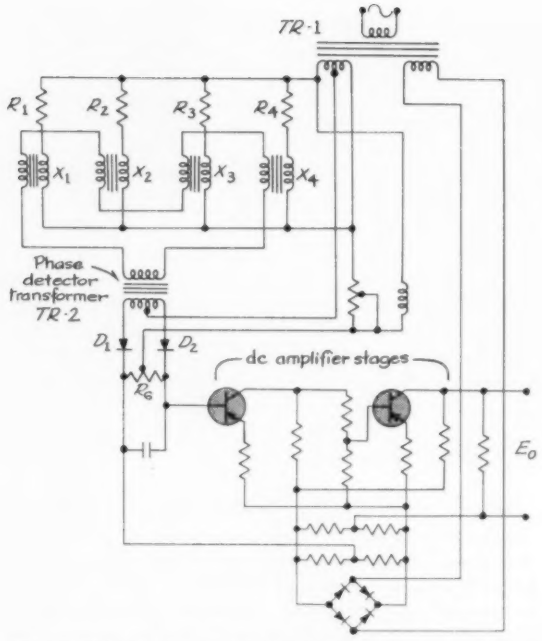


Fig. 9—This circuit provides a dc output voltage that is an analog of the average ac current amplitude and phase in the impedance legs containing resistance bulb sensors R_1, R_2, R_3, and R_4. Current in each bulb passes through the primary winding of an individual reference reactor (X_1, X_2, X_3, and X_4). Secondary voltages are added and impressed across phase detector transformer *TR*-2. The phase-shifted sum voltage is then converted by a phase detector including diodes D_1 and D_2, and resistor R_6, into a dc potential that is proportional to the average phase angle existing between the sensor current vectors and a line voltage reference vector. Amplification by transistors, T_2, left, and T_3, right, provides a 5-volt dc value for E_0 when the average phase shift is 15 degrees, corresponding to an average bulb sensor resistance variation of 25 ohms.

transformer core flux from positive to negative saturation. Such wide swings in core flux are responsible for initiation of alternate transistor firing and cutoff respectively. As long as the input dc signal E_D is greater than a threshhold value of 0.1 volt, it is then possible to obtain a variation in square wave output from this circuit which is linearly proportional to the dc input signal value. A signal strength of 0.1 to 27 volts has been used with this circuit to obtain variations in output frequency which have been used in a suitable indicator circuit.

Transistors are used in one gaging system which does not require their unique electrical properties and hence could employ vacuum tubes as easily, except for two conditions—size and the necessity for heavy batteries. In this application it was necessary to contain a high-gain, battery operated gaging system within the handle of a center-finding gage to be utilized as a fixture included with a boring machine.

The circuit used with this gaging means is shown in *Fig.* 8. An oscillator, including coupling condenser C_1, transformer *TR*-2, and transistor T_1, supplies 2800-cycle excitation to gaging transformer *TR*-1. The secondary output potential of this transformer is then filtered and amplified by a cascaded amplifier composed of transistors T_2 and T_3. Another transistor, T_4, acts as a linear detector in providing a dc output current which is proportional to the ac amplitude of its input signal. Meter *M* will give an indication which is linearly proportional to the displacement of the movable portion of gaging transformer *TR*-1.

In practice, this gaging means has been used for two ranges, with a 0.001 inch and a 0.010-inch full scale meter indication. Drift in scale readings has been eliminated by utilizing large emitter-circuit stabilizing resistances throughout. The average battery life for the miniature batteries employed with the system is 500 hours.

Averaging

An instrumentation system used to average the indications of several resistance bulb sensors is shown in *Fig.* 9. The basic sensor network contains resistance bulb elements R_1, R_2, R_3 and R_4 separately arranged in series with standard reference reactors X_1, X_2, X_3 and X_4. These four circuits are fed in parallel from a common ac source. Secondary windings placed on each of the reference reactors provide ac potentials proportional to the sensor current amplitude and phase angle in each leg. These potentials are summed and developed across phase detector transformer *TR*-2. By virtue of the phase-shifted reference voltage placed into the phase detector, composed of diodes D_1, D_2 and resistance R_6, a dc output voltage is developed across R_6 which is proportional to the average phase angle existing between the individual current vectors and the line voltage reference vector.

Amplification of the phase detector output potential is provided by two-stage transistor dc amplifier T_1, T_2. Included in the output circuit of transistor T_2 is a dc balancing circuit which provides a zero value of output voltage, E_0, when the phase detector output is zero.

A reference value of phase angle is obtained by variation of a phase shifter resistance. Once a given value of phase reference has been set in, further variations above a low reference value, at which the phase reference was set, will result in a linearly increasing output from the phase detector and thus the amplifier.

With the system shown, a variation in average phase angle of 15 degrees, corresponding to an average sensor resistance variation of 25 ohms, will give a 5v dc value for E_0. The advantage of this system is that it does not require a switching means for sampling individual bridge indications as would be the case in a system using separate bridge circuits for each sensor. As a result, it is not necessary to introduce a sampling switch and mechanical unreliability into the system, with its obvious disadvantages.

VACUUM DEPANNER SOLVES BAKERY HANDLING PROBLEM

NOVEL solutions to difficult problems can often be found in unexpected places. For instance, if you were perplexed with the problem of unloading fragile materials from a carrier to a conveyor, would you think of looking in the local bake shop for an answer? Such a problem has faced the baking industry for years. Fresh rolls and buns have fragile crusts that must be carefully handled to prevent crushing or deforming upon removal from baking pans. Formerly, this was a hand dumping operation with subsequent damage to the product during unloading, turning over, and sorting. Now, a machine which uses a vacuum to automatically unload hot breads from pans to a conveyor has been designed and built by Union Steel Products Co.

The USP Depanner, *Fig.* 1, will automatically unload up to 12 pans per minute of single or clustered rolls. Pans of hot rolls can be fed into the machine manually by gravity conveyor or the unit can be connected directly to an automatic unloading oven. A continuous running chain conveyor moves the pans into the lower level of the machine to a pan separator. A clamping unit holds back the pans and feeds them, one at a time, to an air-operated elevator. The elevator raises the pan through a sectionalized wire belt conveyor to the upper level of the machine and holds it momentarily under an adapter plate fitting the configuration of the baked products. A vacuum is applied, and the baked goods, gently but firmly, adhere to the adapter plate. As the elevator retracts to its normal position with the empty pan, the upper level sectionalized conveyor moves under and receives the buns when the vacuum is automatically released. The upper conveyor moves the hot buns out of the machine onto a cooling conveyor as the lower level conveyor takes the empty pan away and loads another full pan on the elevator.

The depanner machine will handle a variety of baked goods. Each roll or bun type requires a separate adapter plate for facing-off the vacuum chamber. Conversion of the machine between different products requires approximately 30 seconds.

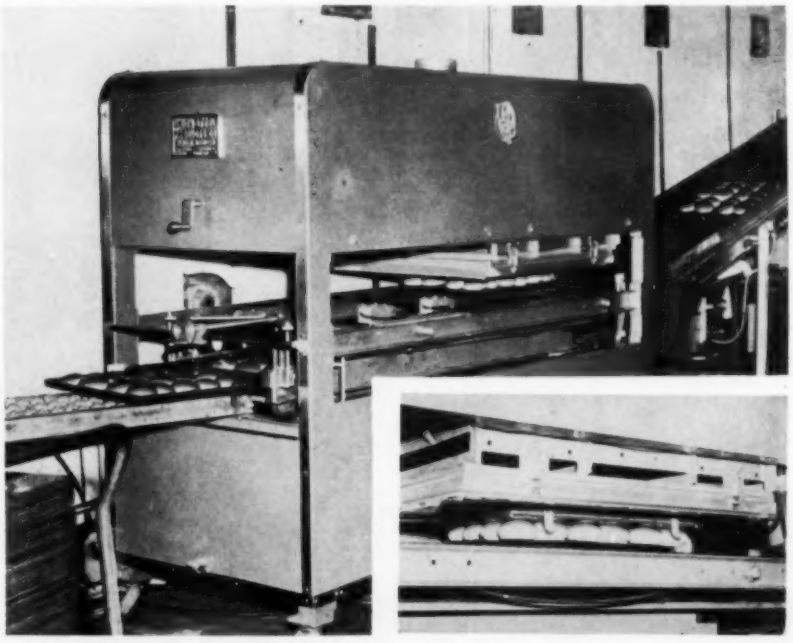
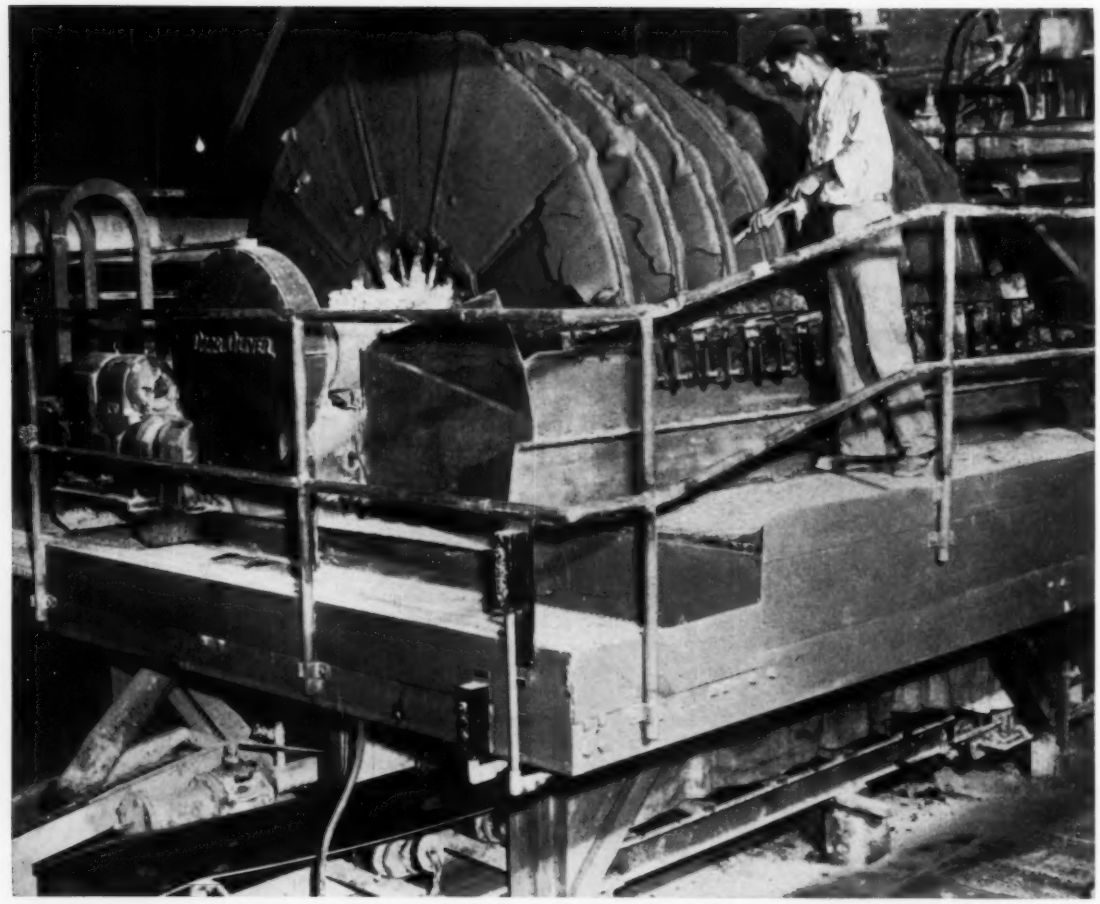
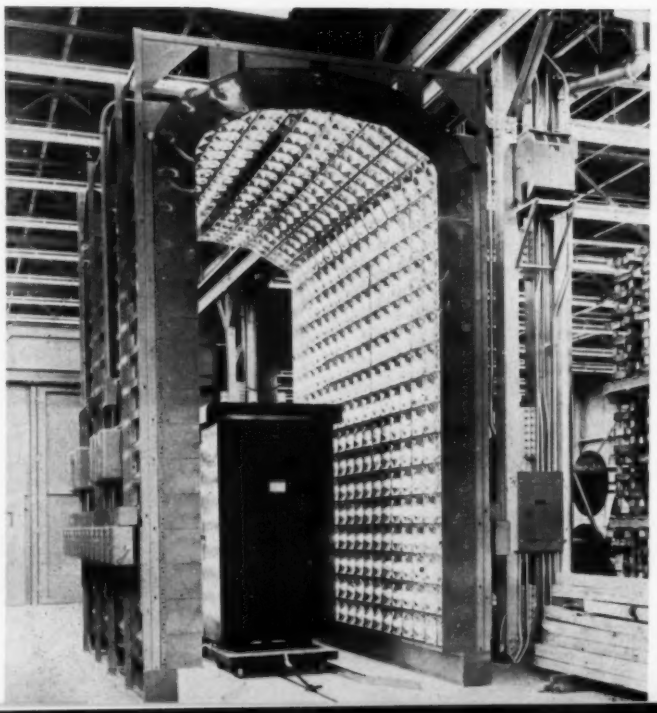


Fig. 1—Depanner automatically removes bakery products from baking pans entering the machine on the left and deposits them right-side-up on a cooling conveyor at right without damaging the oven-fresh products in any way. Insert shows buns being held by vacuum on an adapter plate as the elevator unit retracts and the sectionalized upper level conveyor moves under buns.



Disk-Type Filter

LARGE filter units are fed a continuous stream of blended slurry in manufacture of Portland Cement at Lone Star Cement Corp. plant. The disk-type unit shown includes 10 disks—each disk being composed of 10 pie-shape sections covered with filter bags woven of Union Carbide Corp.'s Dynel acrylic fiber. As disks rotate through a trough of cement slurry, a suction from within each section causes a build-up of filter cake on the bags. As section rotates out of slurry, vacuum is suddenly reduced and filter bag inflated to peel cake off the filter. Continuous conveyor beneath unit collects cake for ensuing kiln burning operation.

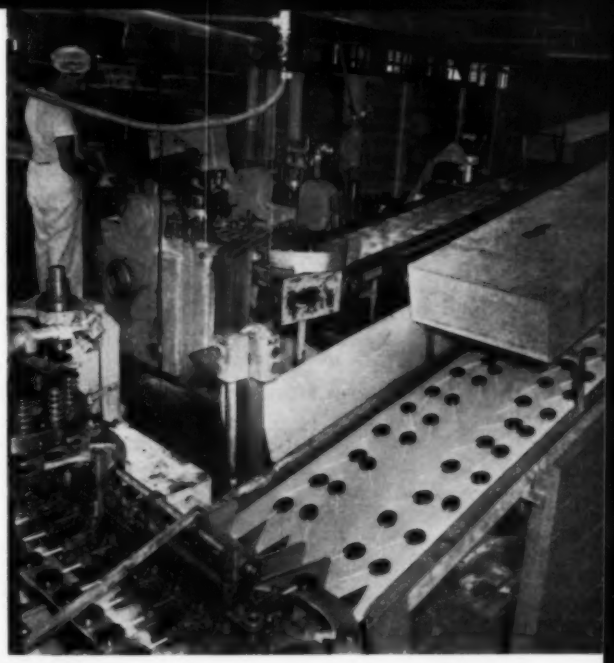


Versatile Oven

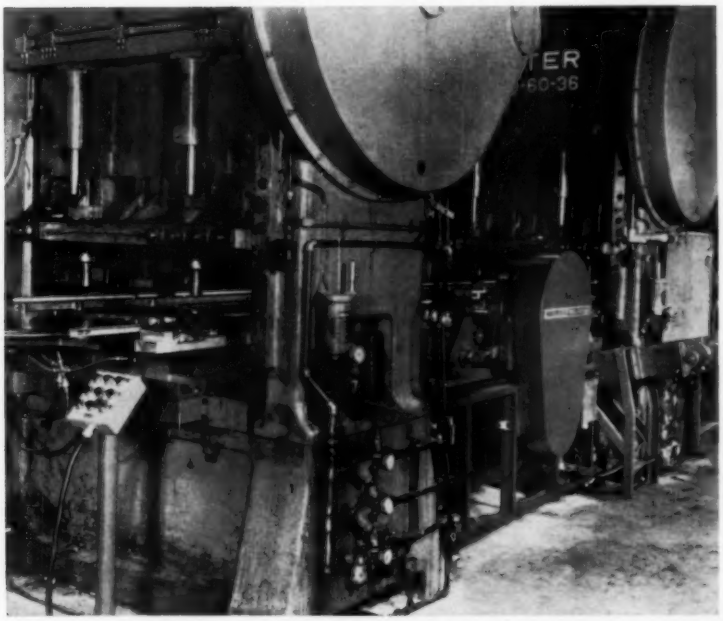
INFRARED OVEN, approximately 15 feet long and 17 feet high, is designed to bake paint on large capacitor housings manufactured by General Electric Co. The oven was constructed to the company's specifications by Fostoria Pressed Steel Corp. To handle different sized units, the oven contains several electrical circuits so that parts of the oven can be turned off when smaller units are being baked. The capacitor housings are pulled through the oven by the floor type conveyor at speeds varying from 6 to 12 inches per minute.

in action

Candy Production



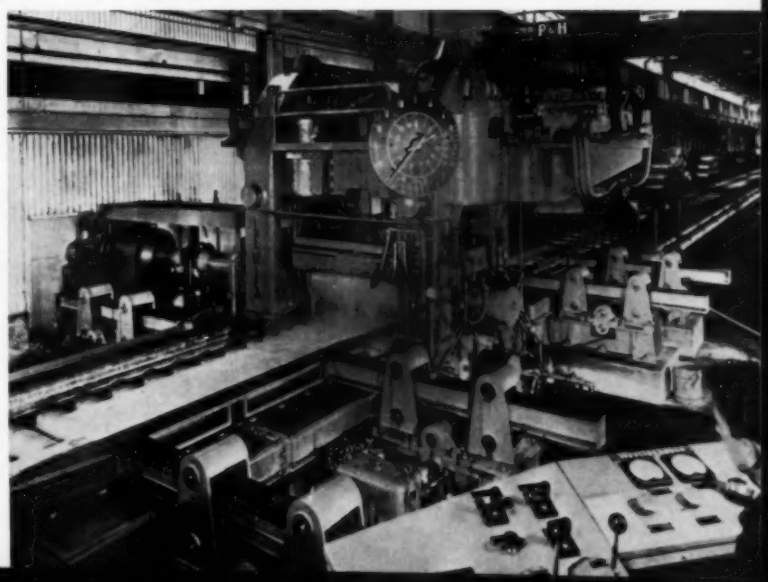
MANUFACTURE of lollipops is a highly mechanized process. This illustration at a Charms Co. plant gives some idea of the extent of automation in producing the quantity of lollipops needed to satisfy the country's sweet tooth. The lollipop is formed in a rotary indexing molding machine. Sticks feed from cartons, in which they are received, into an indexing mechanism which is co-ordinated with the molding cycle for insertion of the sticks into the candy. Subsequently, chain mounted pickups grasp each lollipop by the stick for transfer to a point where the product is dropped onto a conveyor. Improved production operations followed the installation of Koroseal conveyor belting, manufactured by B. F. Goodrich Co., to handle the hot, sticky candy on its move from the molding machine to the packaging department.



Transfer System

PORTABLE transfer unit developed by the Sheffield Corp. is used to convert a series of standard presses into an automatic transfer line. In illustration, three presses have been joined together by the Press Pacer which includes transfer rails and retractable pick-up fingers that move back and forth in transferring stampings between presses. The transfer mechanism is driven from an independent source. Transfer distance can be adjusted from 8 inches up to 3 feet or more; pick-up fingers are interchangeable to accommodate a wide range of stampings in different shapes and sizes.

Rolling Mills



ALUMINUM rolling line at Jackson, Tenn., plant of Aluminum Foils Inc. joins two rolling mills built by Blaw-Knox Co. Ingots 12 inches thick and weighing up to 3000 lb can be accommodated. Illustrated mill is a 30 by 70 inch, 2-high reversing mill driven by a 2000 hp motor. This mill rolls ingots to a finished thickness of 0.25 inch and a maximum width of 64 inches. At the other end of the line is a 15 by 36 by 69 inch, 4-high combination hot and cold unit. Driven by a 1500 hp motor, this mill is capable of rolling aluminum either hot or cold. As a hot mill it rolls to a finished gage of 0.186 inch; as a cold mill it reduces aluminum from 0.186 inch to foil breakdown gage of 0.026 inch.

MAGAZINE FEED FOR ELECTRODES

FEEDING of materials automatically is often as important in use of nonproductive equipment as it is in equipment used to manufacture products. Since basic considerations are similar in both types of applications, automatic feeding arrangements for nonproductive equipment can spark useful ideas for production machine feeders. The feeding device illustrated in *Fig.* 1 and 2 appears to have such potential. This feeder was developed by the Arma Div., American Bosch Arma Corp., for a compact automatic airborne searchlight. Light is generated in the unit by an arc between two carbon electrodes, one positive, one negative. The positive electrode is consumed at a rate of about 35 inches per hour, so several inches of electrode must be available if the searchlight is to be used for very many minutes. The feeder is used to successively feed lengths of carbon electrode material to the arc equipment and thus allows extended use of the light.

Carbons four inches long are stored in a spring loaded magazine, *Fig.* 2, and automatically fed as required. The ends of the carbons are machined with matching internal and external tapers so that successive lengths can be readily joined to form a continuous electrode. When the trailing end of a carbon being fed into the arc passes a pair of clutch dogs, the spring loaded dogs engage the feed mechanism. As the drive motor continues to turn, a slotted escapement tube is rotated and picks off the bottom carbon from the stack in the magazine. Simultaneously a drum cam cocks a spring-return loading slide. When the slot in the escapement tube is rotated to face the loading slide, dogs on the slide engage the new carbon through the slot in the selector tube. As the high point of the cam passes its follower, the loading slide snaps forward and the new carbon is driven into firm engagement with the preceding carbon. The advance of the new carbon also disengages the feed mechanism until the end of that carbon is reached and the cycle is repeated.

The speed of the motor which feeds the positive electrode is automatically regulated to maintain proper focus of the arc. Normal speed of the motor is such that electrode will be advanced at a rate slightly less than the rate of consumption. A reflector and lens system allows a photodiode to sense when the electrode is burning back too far; the motor speed is then increased until the photodiode senses that the arc is again in proper focus.

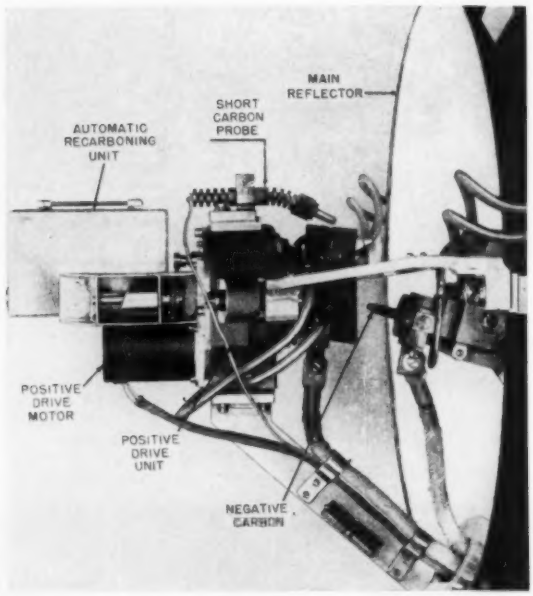


Fig. 1—View of the working mechanism of an airborne searchlight in which positive electrode carbons are automatically fed. Positive carbons (not visible) are fed horizontally to the right toward the negative carbon. The short carbon probe at top is part of a safety circuit which shuts off the arc when the carbon burns too close to the drive unit.

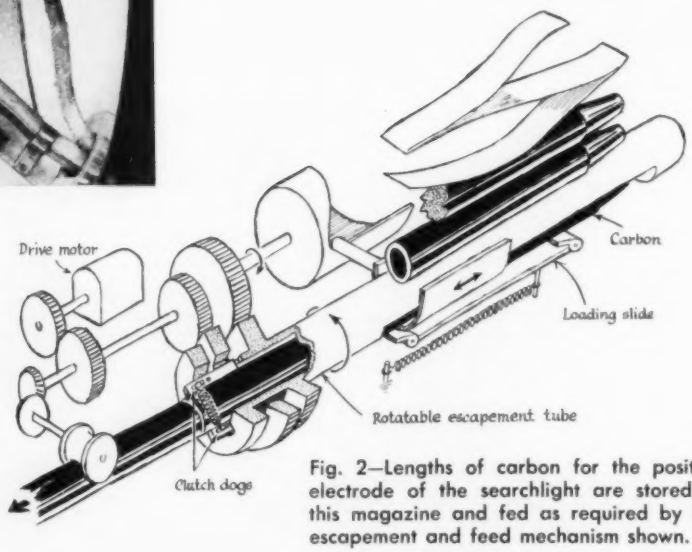


Fig. 2—Lengths of carbon for the positive electrode of the searchlight are stored in this magazine and fed as required by the escapement and feed mechanism shown.

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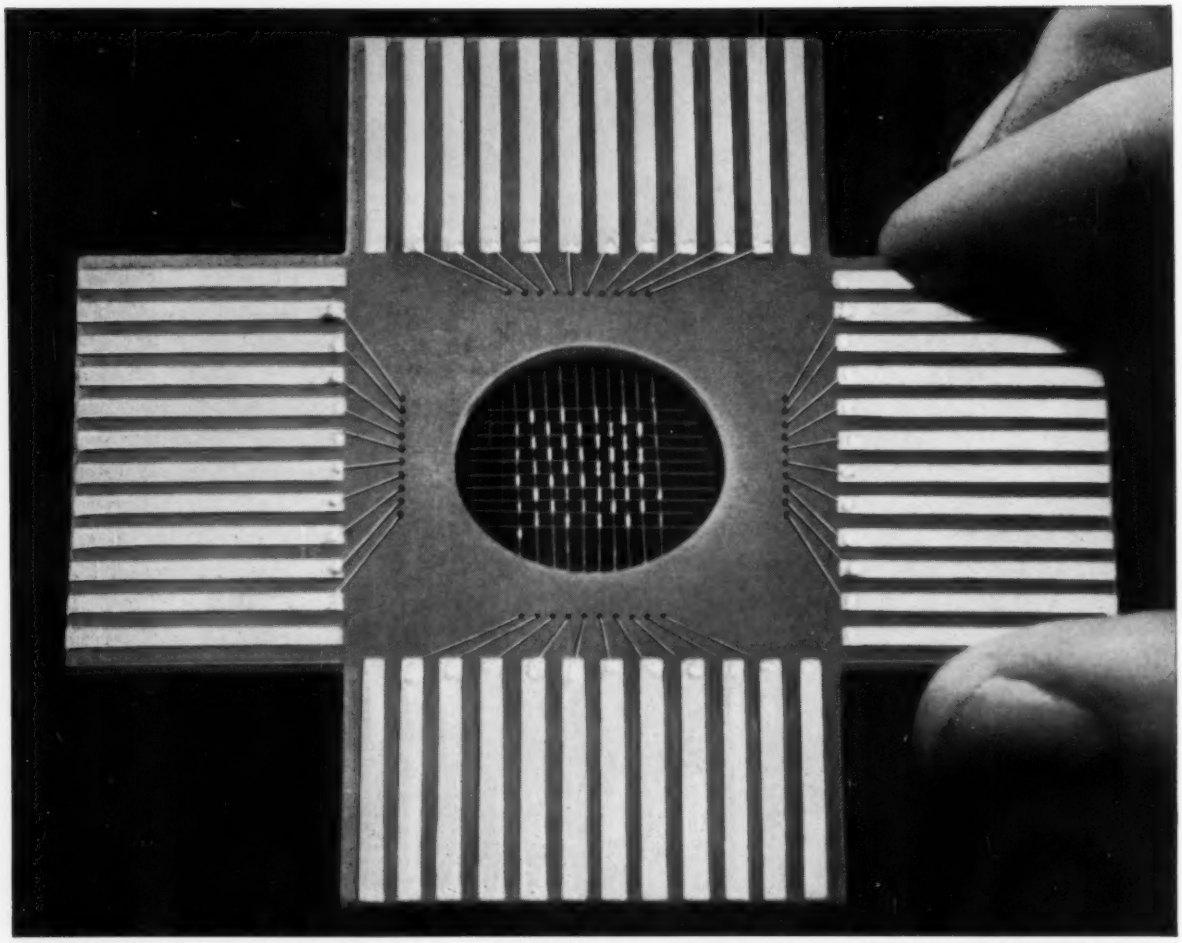

Model (simplified) illustrates basic structure of magnetic "Twistor" memory—magnetic and copper wires interwoven as in a window screen. Twisted condition of the magnetic wire shifts preferred direction of magnetization from a longitudinal to a helical path. One inch of twisted wire, thinner than a hair, can store as much information as ten ferrite rings. "Twistor" was invented at Bell Laboratories by Andrew Bobeck, M.S. in E.E. from Purdue University.

New twist in memory devices

An ingenious new kind of magnetic memory has been developed by Bell Laboratories scientists for the storage of digital information. Known as the "Twistor," it consists basically of copper wires interwoven with magnetic wires to form a grid.

"Twistor" gets its name from a characteristic of wire made of magnetic material. Torsion applied to such a wire shifts the preferred direction of magnetization from a longitudinal to a helical path. This helical magnetization has been applied to produce a magnetic storage device of unprecedented capacity for its size.

In a magnetic memory, information is stored by magnetizing a storage element. In conventional memories the storage elements consist of rings of ferrite. In the "Twistor," they consist of tiny segments of hair-thin magnetic wire. At each intersection of the grid, one such segment is capable of storing a binary digit.

The "Twistor" is simple and economical to fabricate, and its minute energy requirements are easily supplied by transistor circuits. Bell Laboratories engineers see important uses for it in future telephone systems which demand the compact storage of much information, as well as in digital computers for civilian and military applications.

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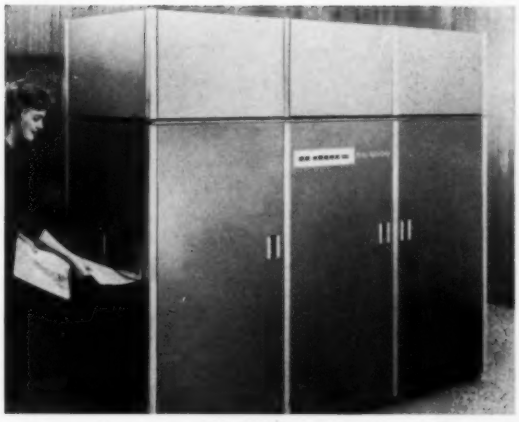
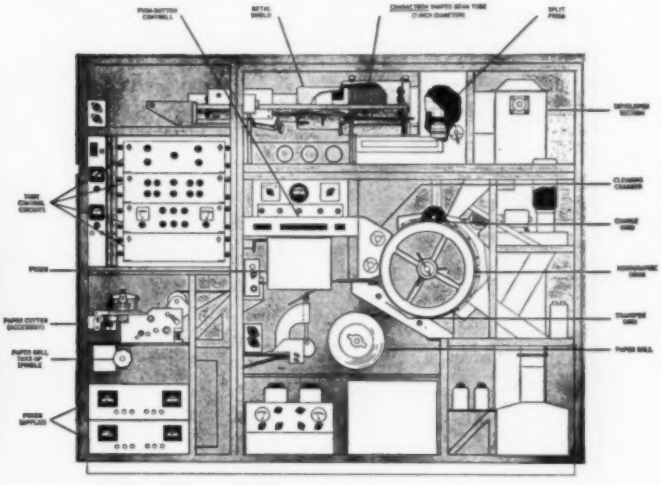




High-Speed Electronic Data Print-Out Machine

EQUIPMENT designed and engineered for large-scale data processing systems has commercial data processing applications such as preparing bank statements, billings, insurance notices, manufacturing control reports, address labels, and missile and aircraft engine data reduction. Unit can be used in either the on-line method of receiving data directly from a computer or the off-line method of receiving data from magnetic tape. Robert C. Tait, president of Stromberg-Carlson, and Joseph C. Wilson, president of the Haloid Co. in a joint statement said the S-C 5000 will print the output of electronic computers five to ten times faster than the speed of present electro-mechanical printers.

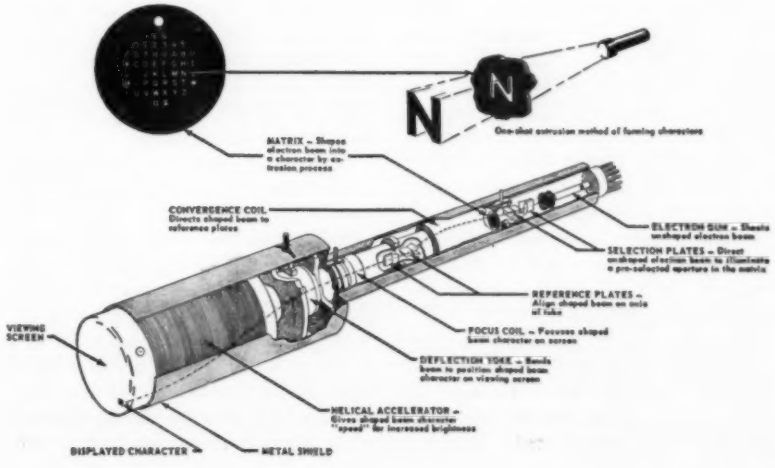
Character Formation

Model S-C 5000 print-out equipment uses a Stromberg-Carlson Charactron shaped beam tube (which writes characters on a cathode-ray screen) in combination with a Xerox-Copyflo printer (which transcribes the images from the tube onto paper).

Instantaneous character generating capability of the Charactron tube provides simplicity of operation as well as high speed. An electron beam is shot from a cathode-ray gun through a preselected character-aperture etched in the matrix. Instantaneously shaped, the electron beam is now in the form of a character, i.e., alphabetical, numerical, or symbolic, and is displayed on the face of the tube. All this is done at the display rate of 10,000 characters per second. It reproduces 64 characters—the letters of the alphabet, 10 numbers, and 28 symbols, of the user's choice.

Printing on Paper

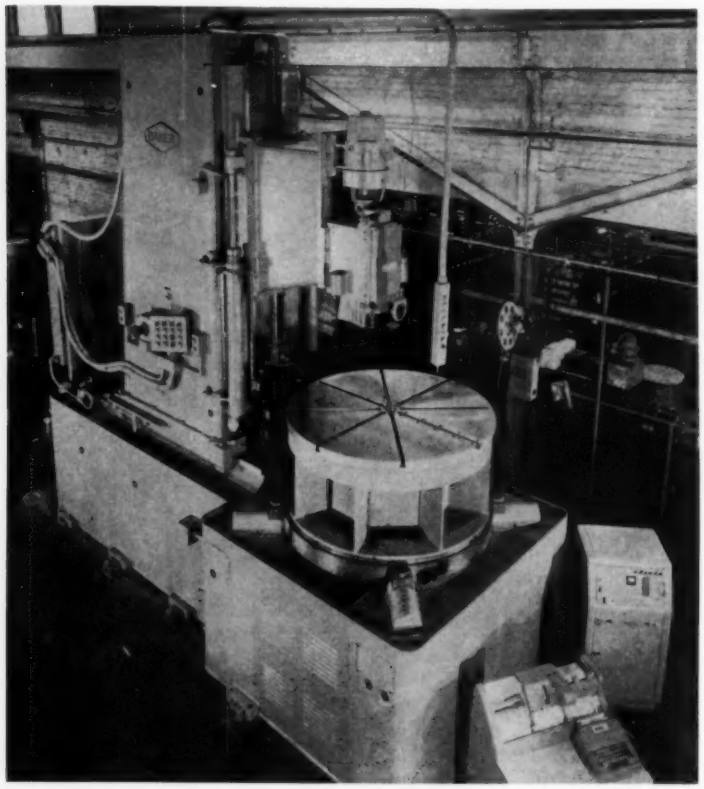
In the printing operation the face of the tube acting as a projector, sensitizes the surface of a selenium drum. The latent



images thus produced are developed with a dry powder, electrically, and then printed on continuous rolls of paper at a rate exceeding an 8½ by 11 inch page every second eliminating liquid developing and fixing agents.

Thus using the Xerox printer of the **Haloid Co.**, Rochester 3, N. Y., the S-C 5000 can print at a rate of better than 4680 lines per minute, with 10 to 15 characters per inch, up to 130 characters per line, and 6 lines per inch. These print-out machines are being marketed by **Stromberg-Carlson, Div. of General Dynamics Corp.**, 1895 Hancock St., Box 2449, San Diego 12, Calif.

Circle 401 on Page 17



Bolt Circle Drill Press

Item 402

Machine is designed for drilling holes on circle diameters from zero to 60 inches. Spacing between bolt circles is variable. The spindle is mounted on a saddle, on a vertical, welded steel frame. Total vertical travel of the spindle is 30 inches with guaranteed accuracy of ± 0.002 inches. Adjustable cams regulate the advance and feed travel of the spindle cycle. Spindle speed is variable between 60 and 3000 rpm.

To drill holes on bolt circles of varying diameters, the vertical frame is mounted on a horizontal slide, allowing movement of the spindle relative to the table center. Maximum travel of the horizontal slide is 30 inches. The slide is set by means of gage rods, and is positioned electronically, and equipped with pinch clamps to hold it in place after the bolt circle diameter setting is made.

The index table is electronically controlled with more than 300,000 positions, permitting any hole spacing around the circumference of the bolt circle to be obtained. Accuracy of the index table is within 0.002 of an inch measured on a 24 inch radius from the center of rotation. After the work has been clamped on the table, the operator adjusts and clamps the horizontal slide for the desired bolt circle radius. When the setup is complete the operator manually cycles the machine to drill the first hole. This hole can be made at any point on the circle. After the first hole is drilled, the table is set at zero by means of the zero off-set. The machine can then be set for automatic operation. Automatic operation of the index is accomplished by a standard IBM punch card system. When the drill cycle is complete, the next card calls for a new table position. This sequence is repeated until all the cards have been run through the reader. **Baker Brothers Inc.**, Post & Harleau Sts., Toledo 10, Ohio.

Circle 402 on Page 17

Sheet Feeder/Stacker

Item 403

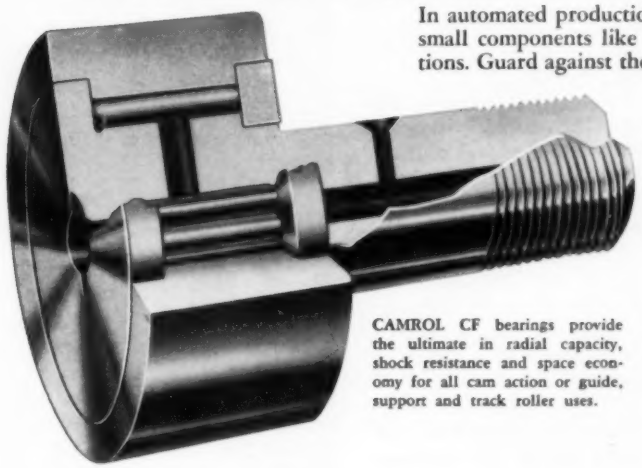
Machine is used to deliver sheets of material such as cardboard, plastics, metal, and asbestos board from piles to processing equipment. It can also be used to remove sheets from conveyors or machine tables for stacking. Sheets can be picked up and delivered horizontally, vertically, or at any angular position. A signal from a timing device, sensing mechanism, or the machine itself starts the feeding cycle.

A suction cup carrier is used for handling sheets. The carrier consists of a frame to which a group of adjustable suction cups is mounted. The transfer frame is in the form of a *U*, the arms being structural channels and the base, a shaft. The carrier is pivotally mounted between the arms, the shaft is oscillated back and forth by a reversible brake motor. A chain and sprocket arrangement acting as a four-bar linkage between the transfer frame shaft and the carrier frame shaft provides positive control of carrier motion and regulates the carrier so it will pick up and discharge at angular positions.

In operation, the transfer frame lowers the carrier until it engages a sheet. Then a feeler switch stops the drive motor, activates the vacuum system so the cups grasp the sheet, and reverses the drive motor so the sheet is transferred to the other side of the machine. When the frame reaches a predetermined position, the vacuum is cut

AUTOMATION TIPS by McGill

CAMROL® bearings ideally suited to anti-friction requirements of automated machinery

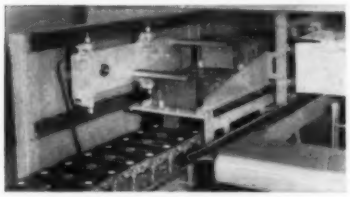


CAMROL CF bearings provide the ultimate in radial capacity, shock resistance and space economy for all cam action or guide, support and track roller uses.

In automated production, even the inefficiency and faulty operation of small components like a cam follower unit can cause costly interruptions. Guard against these failures by specifying CAMROL cam followers. Their quality insures dependability. Their design simplifies lubrication, easily accommodates critical loads and provides low starting and running friction.

Over 20 years of engineering development has gone into the McGill bearing — the first commercial full-type roller bearing cam follower. McGill has employed the advantages of these years of application experience to improve the design and build performance extras into the CAMROL CF, CYR and sealed SCF and SCYR series bearings. All are available in a wide range of standard sizes.

The applications cited below are just a few of the many instances where CAMROL bearings are adding to the dependability of automated machinery.

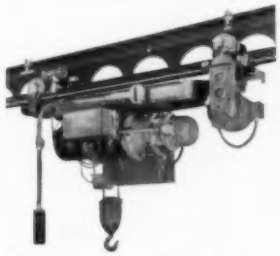


Camrol CF bearings cut power requirements on J. L. Ferguson Co. packaging machines

Used as load-carrying cam followers and as guide rollers in PACKOMATIC packaging machinery, McGill CAMROL CF bearings have brought several desirable advantages to J. L. Ferguson Company in the eight years this firm has relied on CAMROL bearings.

The CAMROL CF bearings eliminate wear by reducing friction. This reduces power requirements and smooths the operation of these machines. The CF bearings are standard, cost less and are more easily applied than previous assemblies.

For trouble-free operation, up to 50 bearings per machine are now used by this company.

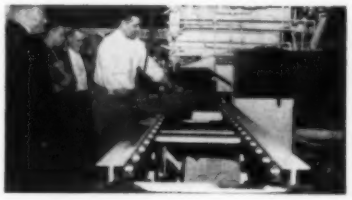


Cleveland Tram Rail guides motor heads on McGILL Camrol Bearings

Motor-driven electric hoist carriers made by the Cleveland Tramrail Division of the Cleveland Crane and Engineering Company, incorporate McGill CAMROL Cam Follower bearings as side guide rollers for the motor head.

Replacing spring loaded friction type bolt or roller units, the CAMROL cam followers provide dependable, free running operation of the carrier assembly and provide simplicity of mounting and lubrication with trouble-free performance.

Bearing performance has been most satisfactory through almost six years of use.



Camrol CF bearings provide friction-free track rollers for automatic mold blower

McGill CAMROL CF rollers are used as track rollers to form a mold conveyor in the Beardsley & Piper MBS-20 Mold Blower. The CAMROL CF bearings replaced built up friction rollers in this application. Although the duty here is rather light and the speeds slow, the cam follower bearing provides less starting and running friction. This helps speed the even flow of work from the machine, which must be fast and automatic. The compact unit, with integral stud, simplifies assembly and lubrication. Availability of a standard bearing is more convenient and less costly.

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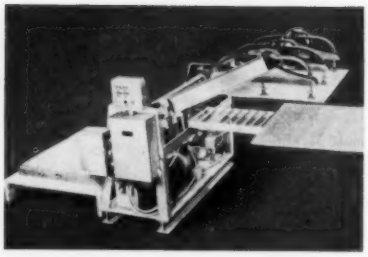
Insure performance with McGILL®

MULTIROL® GUIDEROL® CAMROL®
Precision Needle Bearings

McGILL MANUFACTURING COMPANY, INC., 401 N. LAFAYETTE ST., VALPARAISO, INDIANA



off and the sheet discharges. The arms automatically return for another sheet. If vacuum at any cup is broken, the arms will not lift a sheet. **de Florez Co. Inc., Div. of Dexter Co.,** 116 E. 30th St., New York, N. Y.

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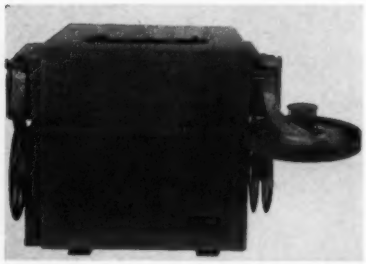

Tape Transmitter-Receiver

Item 404

Instrument is capable of transmitting and receiving data encoded in five, six, seven, and eight channel tape. It is used at the ends of a communication channel to transmit and receive coded information between other locations. Machine has a tape reader and a punch. The reader is in operation when transmitting information. The punch is in operation when receiving information. As data in punched tape are transmitted through the reader of the machine, it is simultaneously reperforated and checked on the punch of the Teledata placed at a distant location. This tape can be used to actuate other equipment to automatically produce documents such as sales, orders, invoices, and production orders.

The equipment can operate over any commercial telegraph channel. The transmitted signal is in the form of direct current, neutral impulses either from the internal power supply or from an external source. A conventional telegraph line relay is used for receiving either polar or neutral signals. The telegraph channels must be free of mechanical regenerative repeaters and automatic switching equipment when the unit is used to transmit any code involving more than five bits. **Friden Calculating Machine Co. Inc.,** San Leandro, Calif.

Circle 404 on Page 17

Bagging Scale

Item 405

Portable high-speed bagging scale features an eye-level counter for tallying the number of bags filled. The scale weighs and fills open mouths of textile bags with fertilizer, feeds, grain, rock products, chemicals, food products, tobacco, and a variety of similar materials. It is fitted with a detachable and changeable bag spout to accommodate 25 lb, 50 lb, or 100 lb bags.

In operation, with power on and weigh hopper empty, the counterweighted end of the weigh beam is down. This position causes the inlet-gate air cylinder solenoid to be energized and the inlet gate is opened. When the preset weight

of material is received in the hopper, the beam moves toward balance, closing the inlet gate and stopping the feeding action. Then a mechanical linkage is automatically tripped, discharging the material from the weigh hopper into the bag. The rate of material flow into the inlet chute is regulated by a slide which increases or decreases the inlet opening. For gravity-fed sluggish materials, an agitator can be provided in the inlet chute. **Richardson Scale Co.,** Van Houten Ave., Clifton, N. J.

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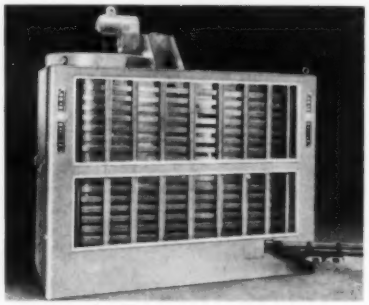

Parts Storage Unit

Item 406

Storage unit is designed for parts that can roll. Each unit is assembled from standard components, and is custom tailored to a specific job. Parts are kept moving along guide tracks by two belts rotating lengthwise in the unit with the belt surface vertical.

In operation, the parts are gravity fed to an entry in the base of the unit and roll into internal tracks. The parts are retained in these tracks and follow an elongated spiral to the top of the unit where they are demand fed by gravity to the next operation. The parts are kept in motion by one of the two sections of rubber belting rotating within the unit. The metal guide tracks on which the parts roll are tilted slightly so the parts lean against the vertical surface of the belt. Movement of this belt makes the parts roll up the inclined track by light friction. The light friction retains the parts from slipping if the unit is stopped for any reason. As parts leave the retaining tracks at the upper level of the equipment they are gravity rolled to the exit chute takeoff. The parts can be positioned vertically or horizontlly for the following machine operation. A limit switch in the exit chute automatically shuts off the equipment if parts back up from the subsequent operation. When used for stockpiling of parts, the equipment automatically stops when full capacity has been reached. This is done by the actuation of double limit switches at the parts entry

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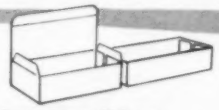
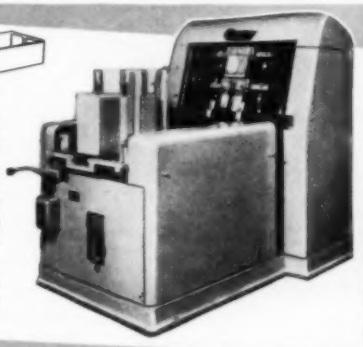
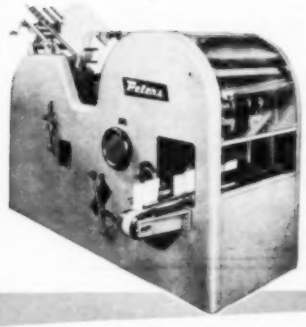
Whatever your product, packaging is important to your company. The *right* packaging system improves your earnings. How? By packaging more units faster . . . by reducing handling costs . . . by minimizing damaged goods . . . by adding sales appeal. Whether a standard Peters packaging machine or Peters equipment *custom-engineered* to your particular need, *investigate today!*

Closes up to 150 cartons per minute. Peters Model CCY Carton Folding and Closing Machine automatically folds and closes **unlined** cartons. Model CCY-L closes **lined** cartons. Carton size range: 3½" x 2" x 2" up to 12¾" x 7" x 4½".



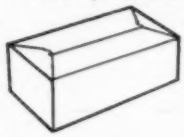
Produces up to 175 cartons and trays per minute. Peters Model SG-P Carton and Tray Forming and Gluing Machine automatically converts low cost blanks into perfectly shaped glued or heat-sealed cartons and trays for packaging cookies, crackers and specialty products.

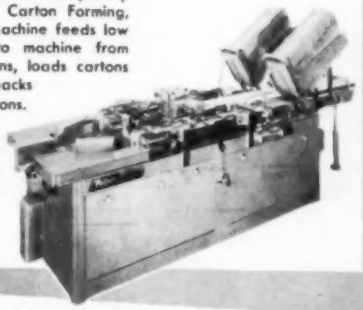




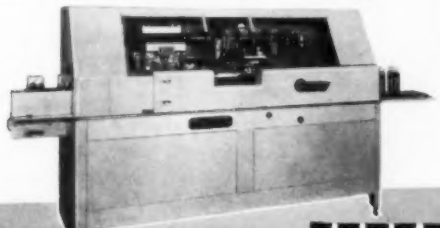
Forms and lines up to 120 cartons per minute. Peters Model SE Carton Forming and Lining Machine automatically cuts rolls of liner paper to proper size . . . then folds liner paper and carton blank together to form lined cartons. Can be made adjustable to set up a wide range of carton sizes.

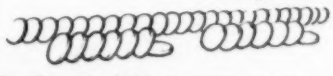
Forms, Loads and Closes up to 120 cartons per minute. The new completely automatic Model CCK Carton Forming, Loading and Closing Machine feeds low cost carton blanks into machine from hoppers, sets up cartons, loads cartons with wrapped cracker packs and securely closes cartons.





Seals bags and applies labels at speeds up to 70 per minute. Peters Model L-2 Bag Sealing and Header Applying Machine receives filled gusset-type cellophane bags from packing conveyor, times them into machine, tucks gusset, applies header or label, heat-seals bag and label, and discharges completed package.





Developed for 1400-per-minute cookie packaging . . . adaptable to any cookie-size product! Peters GTB attachment delivers products from production line **stacked or flat,** depending on type of package . . . in **groups or continuous rows,** depending on packaging system . . . and **in two rows or four rows** to enable fewer workers to pack product in bags, trays or cartons.

Peters

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WHAT'S YOUR PRODUCT?

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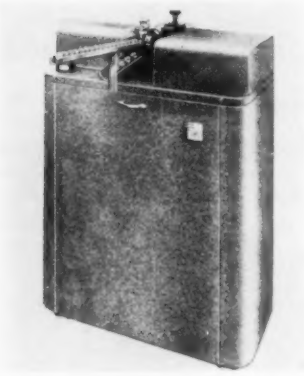
to the unit. **Gear-O-Mation Div., Michigan Tool Co.,** 7173 E. McNichols Rd., Detroit 12, Mich.

Circle 406 on Page 17



Commutator Slotter

Item 407

Device is capable of notching 600 twenty-eight bar commutators per hour by simultaneously cutting two lead wire slots each machine index. Model 2000 can notch commutators up to 1½-inch in diameter and 1½-inch in length. It can be adjusted to a new size in approximately twenty minutes. The machine will run until the loading magazine is empty, and shut itself off. **Motor-Mation, Inc.,** P. O. Box 2145, North Canton, Ohio.

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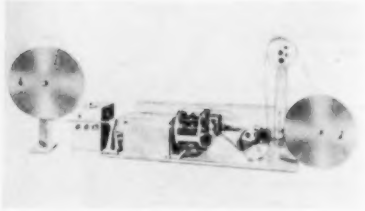

Resistance Winder

Item 408

Machine is designed to wind resistance wire helically onto continuous lengths of flat or round core material that are advanced axially through the winding head. It can wind onto any material that can be drawn through a ¼-inch ID spindle. Applications for round material include wirewound resistors for both automatic and manual assembly and thermal applications such as heating elements for electric blankets and heating pads. Applications for flat material include continuous windings for rheostats, attenuator elements, and flat card resistors. Wound material can be drawn through an adhesive solution since it travels about 36 inches in the open, permitting material to dry before reaching take-up spool. Variable speed control permits uniform torque in winding at speeds as low as 200 rpm and as high as 1400 rpm. Winding speed is not affected by fluctuations of the 115v 60 cycle supply. **Geo. Stevens Mfg. Co.,** Pulaski Rd. @ Peterson, Chicago 30, Ill.

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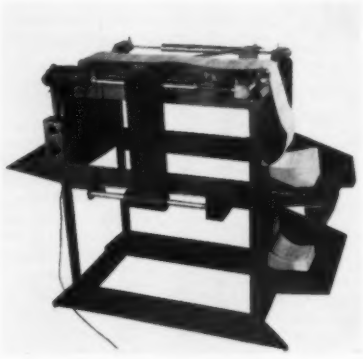


Office Form Separator

Item 409

Unit can be used independently or in conjunction with tabulating equipment and computer output printers. Friction and pinfeed are used to process continuous forms after they have been run over any type of office machine. The action of the unit provides for straight line carbon removal and forms separation or straight line forms separation with side removal of carbon. Carbons can be fed to rewind spindles or deposited in waste containers while forms go to individual refold trays.

Optional equipment which can be furnished includes a motor driven pinwheel device to feed marginally - punched continuous forms into a separator with variable speed control; pairs of slitter knives capable of slitting the equivalent of eight parts of #12 paper and carbon; a booster roll attachment providing feeding assistance where gravity feed is not sufficient for proper separation; and a carbon rewind attachment which provides a quick and efficient means of disposing of individual piles of carbon. **Standard Register Co.,** Dayton, Ohio.

Circle 409 on Page 17

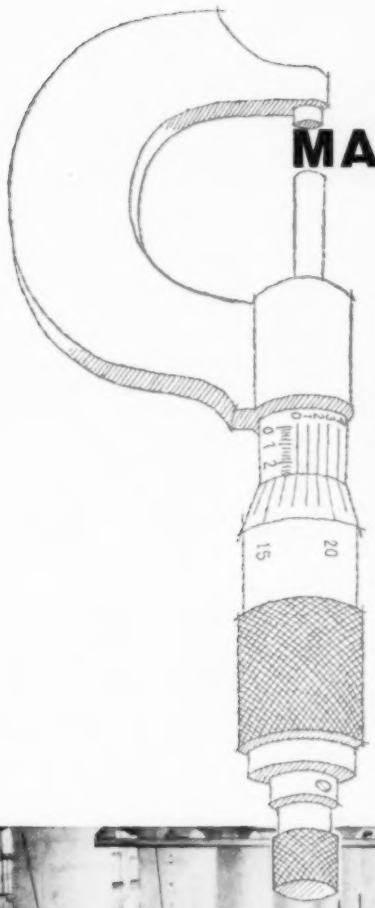
Chamfering Machine

Item 410

Single-station unit, Model BMI-15M deburrs and chamfers slots around the periphery of a part at production rates of 200 parts an hour. In operation, parts are manually loaded in the work station and a radial locator is actuated by the operator to assure positive part positioning. As the machine drive is started, the quill comes down and the part is automatically air-chuck clamped. The parts locator is then retracted and the cutting cycle is started by the operator pushing two pushbuttons mounted on opposite sides of the machine for maximum safety.

The cutting cycle energizes an electric counter that controls the slot chamfering. At the end of the proper number of strokes, the counter automatically stops the cutters in a retracted position, the part locator re-enters the part, the part is unclamped, and the quill is raised. The operator then unloads the part. Automatic indexing from slot to slot takes place during the return stroke of the tools. When the chamfering operation is completed, the machine comes to a full stop with the cutting tools safely and fully retracted. **Modern Industrial Engineering Co.,** 14230 Birwood Ave., Detroit 38, Mich.

Circle 410 on Page 17



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Call on one of Canco's four complete shops!

The Nation's largest metal container producer—American Can Company—is a pioneer in AUTOMATION. Its four machine shops produce the equipment which makes AUTOMATION a fact. The machine shops are staffed with experienced engineers, designers and machinists—who can design and manufacture for you any high-speed precision machinery, as well as dies, fixtures, tools and individual parts.

The shops are located at:
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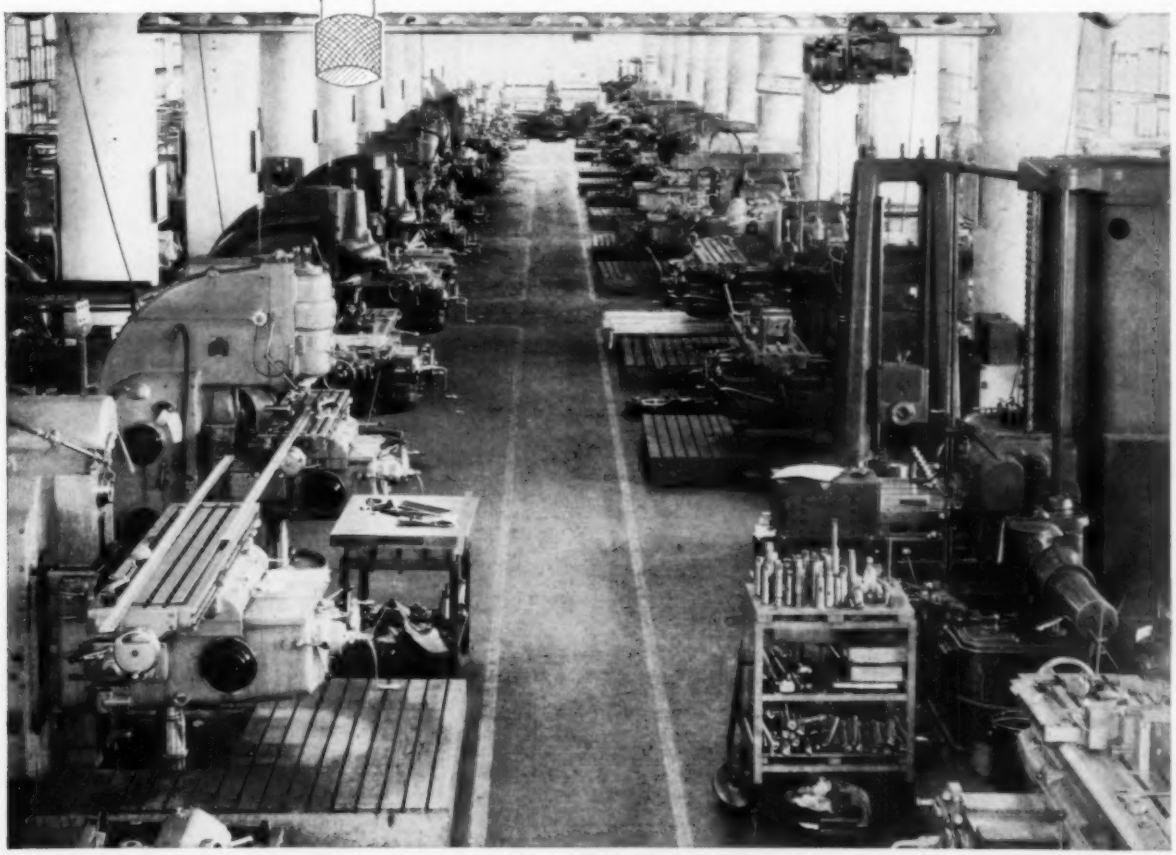
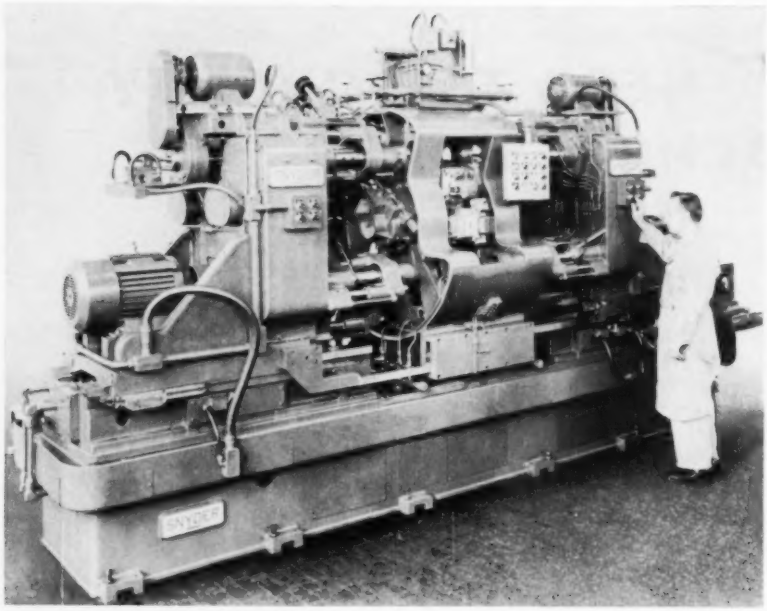
320 Elizabeth Avenue, Newark 12, N. J.
Spring Grove Ave. & Fergus St., Cincinnati 23, Ohio.
499 Alabama Street, San Francisco 10, California.

These extensive facilities are available to you for contract and sub-contract work. Your inquiry is invited and should be addressed to the machine shop nearest you.

American Can Company





Special Purpose Machine

Item 411

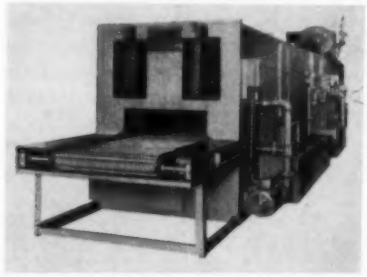
Unit drills, core drills, reams, and taps four different groups of more than 58 coal mining machine rock bit holder parts. Fixtures are mounted on a trunnion which is indexed to five positions between opposed standard way - type machining units. One machining unit has a nine - spindle head and a single-spindle lead-screw tapping unit, and the other has a ten-spindle head and a single-spindle leadscrew tapping unit. Holes up to 1½-inch in diameter are drilled and reamed in the parts.

Variations in the four groups of steel parts processed by the machine depend on the size and shape, number of holes, hole location, and hole sizes. The part size and shape variations are accommodated by interchangeable fixture details. The variation in number of holes is handled by utilizing two-position fixtures. A part is put in one fixture position and indexed through four machining stations, then put in the other position and indexed through four more machining stations.

Variations in hole locations are provided for by three removable, interchangeable, two-spindle heads on each of the main heads of the machine. Heads are interchanged to accommodate proper center distance specifications for the various parts. Adapter assemblies permit adjustment of tools for length. When the machine has been set up for a specific group of parts, a part is loaded in the first station and a button is pushed. The two

heads advance for the machining operation and retract. As the heads retract, the trunnion indexes counterclockwise to the next station. Operation of the pushbutton again causes the heads to go through their *advance* and *retract* sequence. A finished part is produced with each index of the trunnion. **Snyder Tool & Engineering Co.**, 3400 E. Lafayette, Detroit 7, Mich.

Circle 411 on Page 17



Parts Cleaner

Item 412

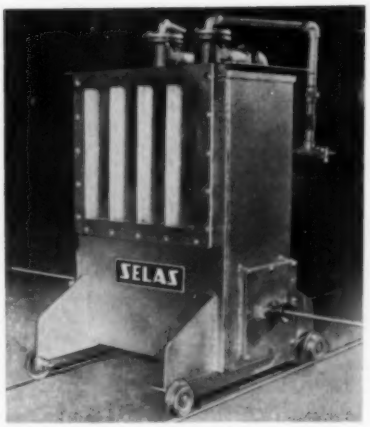
Unit does all cleaning operations in one central area, avoids frequent rehandling of parts. Two overhead conveyors and a flat wire mesh belt conveyor pass through the machine which uses an automatically timed wash-rinse-dry cycle. In operation, parts are placed on the appropriate conveyor according to subsequent operations to be performed on them. For example, while one overhead conveyor is carrying parts to subassembly from the washer, the other trolley conveyor may be routing parts through painting and drying operations. The flat wire mesh belt conveyor handles parts which cannot be cleaned and dried when suspended from an overhead conveyor, and parts routed to other destinations, such as storage. The conveyors can be operated simultaneously or individually. **Alvey-Ferguson Co.**, 1911 Disney St., Cincinnati 9, Ohio.

Circle 412 on Page 17

Production Furnace

Item 413

Machine is capable of heat-treating high temperature materials in wire and rod form, continuously at high linear speeds. For heating tungsten and molybdenum rod for



swaging, the furnace heats rod at any rate required by the swager. Typical production is 80 ipm of 0.350-inch diameter tungsten rod from room temperature to 2700 F using only 65 cfh natural gas. The furnace is wheel-mounted for easy removal from the swager when not in use. During operation, the steel casing in the furnace remains cool, and the working area comfortable. **Selas Corp. of America**, Dresher, Pa.

Circle 413 on Page 17

Westinghouse CYPAK takes the "mix up" out of cake mix storage conveyors

Chelsea Milling Company, maker of well-known "Jiffy" brand premixed foods, uses flexible Cypak* static control to reduce materials-handling costs at its plant in Chelsea, Mich.

Starting at the mixing and packaging machines, Cypak control memorizes the sequence of cartons going to the warehouse . . . maintains carton identification automatically . . . directs storage according to the preselected pattern. In addition, Cypak predetermines subsequent delivery to the loading dock.

Result: substantial savings have been realized through reduced handling and carton breakage.

For complete information on Cypak, call your Westinghouse representative. Or, write Westinghouse Electric Corporation, 3 Gateway Center, P.O. Box 868, Pittsburgh 30, Pennsylvania.

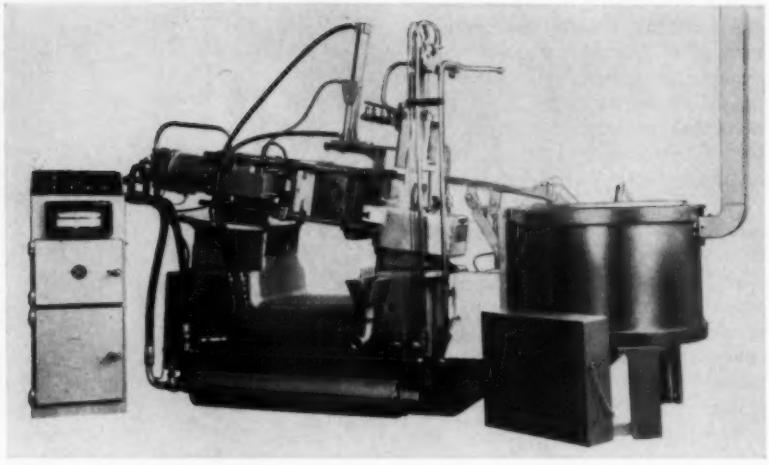
J-22094

*Trade-Mark

POWER-UP starts with CONTROL

YOU CAN BE SURE...IF IT'S Westinghouse

Circle 714 on Page 17



Die Casting Machine

Item 414

Machine produces zinc alloy castings up to 1 lb in weight, at production rates of 1500 shots per hour. Operations and controls include machine cycling, die cleaning and lubricating, inspection for foreign matter in the die, water control, replenishing molten metal supplied to machine, and picking of castings. The automatic die cleaning and lubricating mechanism operates from a separate control box on the die unit. As the casting is ejected, brushes wipe over both die faces, cleaning off flash and knocking casting off ejector pins. Brushes are set in an adjustable holder to take variations in die contour. Brushes wipe die again on up stroke and cycle repeats. As dies close, a measured unit of lubricant is blown onto the die faces.

A liquid level controller keeps molten metal at a predetermined level. When the level of the molten metal in the machine pot drops sufficiently to break the two-probe circuit, the ladle device is energized and automatically refills the machine pot. A thermostatic control on an adjustable solenoid-operated water valve controls the water manifold. A pressure switch senses the presence of foreign matter between the dies as they lock up. Unejected casting or foreign matter will cause the die to retract and stop the cycle. An additional pair of limit switches assures die lockup at each corner and prevents injection in case of flash or dirt. Instead, the machine will recycle and reclean the dies.

In operation, as the die closes it is automatically lubricated, and the flash sensing device determines if the die is clean and free from foreign matter. The dies lock, closing dual safety limit switches at opposite platen corners. The injection plunger comes down and the plunger dwell timer times out plunger dwell and squeeze. Solidification dwell timer takes over and times out. The dies open and the part ejects. The die cleaning brush timer times out, activating brush air cylinder which cleans the faces of dies and retracts, activating limit switch to repeat the cycle. **DCMT Sales Corp., Div. of British Industries Corp.,** 80 Shore Rd., Port Washington, N. Y.

Circle 414 on Page 17

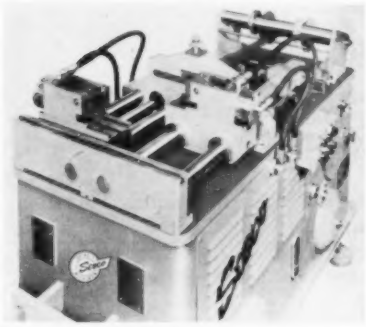
Press Feed Unit

Item 415

Device has a twin-cylinder design, can be attached to a production press to feed from the right, left, front or back, and can be timed to feed-in during any preselected portion of the press cycle. The crosshead arrangement includes two grippers, each operated by a hydraulic feed cylinder. The cross head cylinders are sequenced so that while one gripper grips the stock and moves it forward, the other gripper is returned for the next feed stroke.

The adjustable hydraulic feed cylinders have a two-piece piston inside each cylinder. A stroke handle on the side of the unit adjusts the pistons. Shock absorbers prevent impact at each end of the cylinder. Reciprocating travel of each pinch gripper is governed by the stroke adjustment within the cylinder. Through proper sequencing the pinch grip takes place before any forward feeding is possible, and the grip is not released until the forward motion has been completed, eliminating over-travel.

A rear stock guide assembly pro-



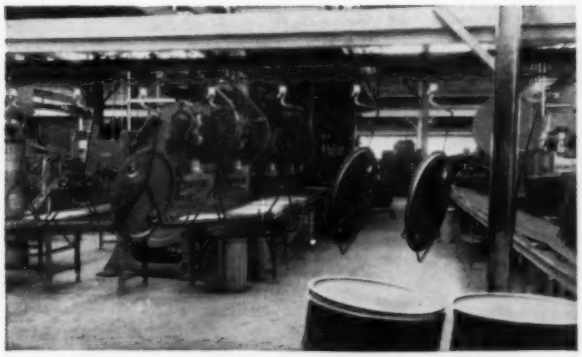
vides proper alignment of the stock with the feed assembly, and is adjustable to handle various stock widths. A similar guide assembly in the front directs the stock properly into the die. **Sesco Inc.,** 8881 Central Ave., Detroit 4, Mich.

Circle 415 on Page 17

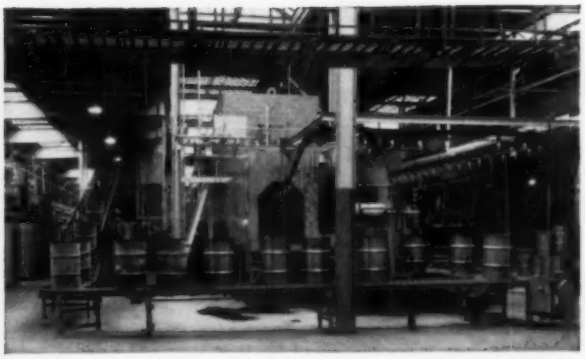
Tableting Press

Item 416

High speed unit is capable of producing up to 3500 compressed tablets per minute from powdered

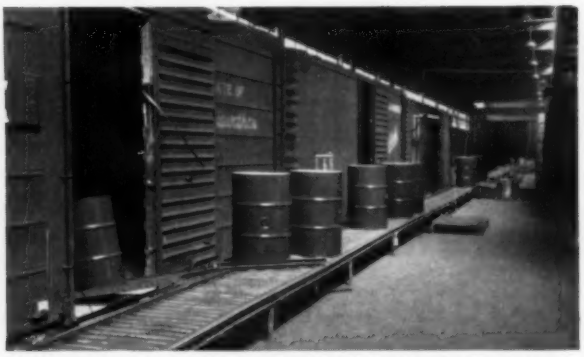


Drum heads move like clock-work during forming operations via Alvey conveyors at U. S. Steel's new Camden plant. Conveyor movement is so well synchronized and coordinated, not a minute's production time is wasted.



Drum shells emerge from wash unit on their sides, are upended . . . then travel along Alvey live roller conveyors to incline belt, which carries them to another area for further processing.

Drums, en route to loading dock, move down Alvey declined conveyor and smoothly transfer to horizontal conveyor. Exclusive declined conveyor design permits easy, "floating" ride, with no bouncing or jamming up at point of transfer.



Alvey roller conveyors along railroad siding feed finished drums into box cars. System enables U. S. Steel Products to load up to 26 cars, inside and outside of building. Similarly, 12 trucks can be loaded at nearby loading dock.

High-speed steel drum production . . . low-cost handling with Alvey-Engineered Conveyor System . . . at U. S. Steel Products Div. Camden Plant

U. S. Steel Product's objective: high-speed, streamlined production and highest materials handling efficiency at their Camden, New Jersey plant with lowest possible handling costs. Alvey's answer: a completely coordinated Conveyor System. Results: maximum drum and pail production; plus a minumim of handling costs.

From unloading of raw materials to the shipment of finished products, this plant is a conveyor-integrated manufacturing operation. More than 6000 feet of Alvey conveyors automatically carry drums and pails up and down, through baking ovens, and on through various production lines to rail and truck loading docks for shipment. Time-saving Alvey equipment, such as inclined conveyors, belt conveyors, live roller conveyors, have enabled U. S. Steel Products to achieve split-second synchronization . . . *completely* automatic materials handling.

Whether you require an individual conveyor or a complete system, Alvey can meet your exact needs. Experienced Alvey engineers will give you full details . . . write or wire today!

ALVEY

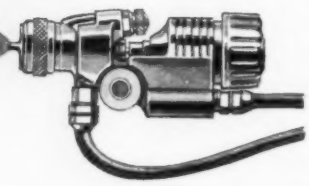
292

ALVEY CONVEYOR MANUFACTURING COMPANY

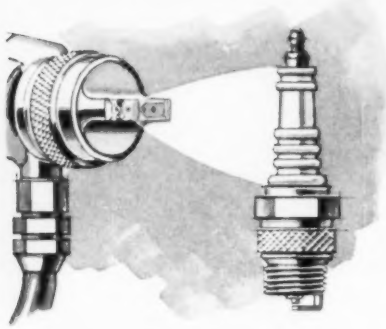
9373 OLIVE STREET ROAD • ST. LOUIS 24, MISSOURI • *Branch Offices in Principal Cities*

They solved it with...

AUTOMATIC SPRAY



9600 spark plugs per hour are glazed automatically by an Ohio spark-plug manufacturer. The installation of a pair of DeVilbiss Automatic Chain-On-Edge Machines has resulted in valuable economies for this company. Not only are the usual savings of time, labor and reduction in waste materials gained; but, more significant, the operation is exceptionally simple, trouble-free, and easy to adjust and maintain. Finished plugs are of a more uniform quality than ever, too.



★ ★

Now you can have your cake at the rate of 80 per minute thanks to a DeVilbiss installation for an Illinois cake-mix manufacturer. Previously, the glassine inserts tended to collapse as they were forced into the packages by compressed air. DeVilbiss spray guns on the conveyor now puff-spray a fast-setting adhesive to a small area inside each box, keeping the inserts in place. The entire operation is automatic; and a bothersome problem has been eliminated.

★ ★ ★

Have *you* a coating problem? Let DeVilbiss research experts determine whether or not it can be automated. DeVilbiss spray equipment is designed to meet *your* specifications and more than likely will save you time and money. Won't you call or write us? *The DeVilbiss Company, Toledo 1, Ohio; Barrie, Ontario; London, England. Branch offices in principal cities.*

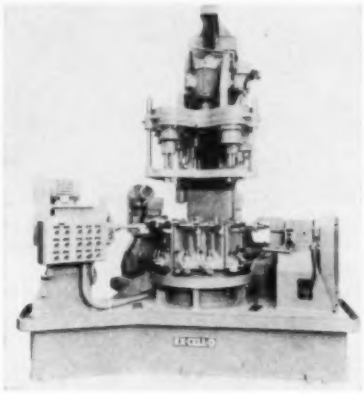
FOR BETTER SERVICE, BUY
DEVILBISS

Circle 696 on Page 17

granulations. Model 249 has a compression pressure of 9000 lb and removable twin stainless steel hoppers. Controls located at the front of the machine include handwheel adjustments for tablet weight and thickness, speed control handwheel, a handwheel for jogging the press for setup operations, and a knob pullout slide for quick punch removal.

Press has a combination tachometer-counter unit which indicates die table speed and tablet production count. A clamp ring eliminates die lock and avoids die push-up during operation. **Arthur Colton Co.**, 3400 E. Lafayette, Detroit 7, Mich.

Circle 416 on Page 17

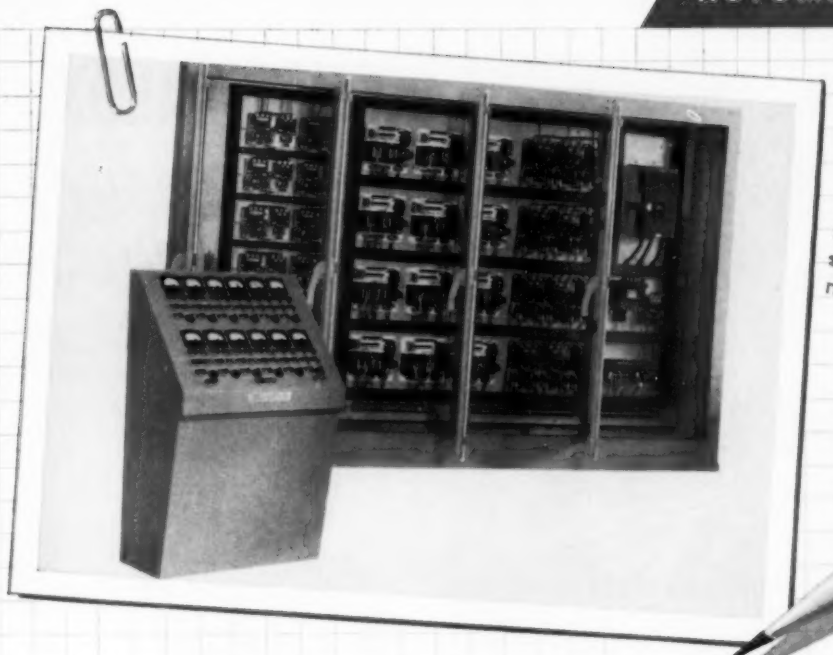


Multispindle Machine

Item 417

Five-station unit performs drilling, tapping, spot-facing, counterboring, and chamfering operations on cast iron distributor bases. An electromechanical indexing table carrying the five-station, two-compartment fixture is centrally mounted on the base. Adjacent to the fixture table are three standard hydraulic power units and a tapping head for horizontal and angular operations. The vertical column of the machine carries a multispindle drill head mounted on a hydraulically operated slide.

In operation, the parts are manually loaded into the right hand compartment of the fixture. After a complete revolution of the indexing table, the parts are unloaded and reloaded into the left hand compartment. The fixture again indexes around the work stations,

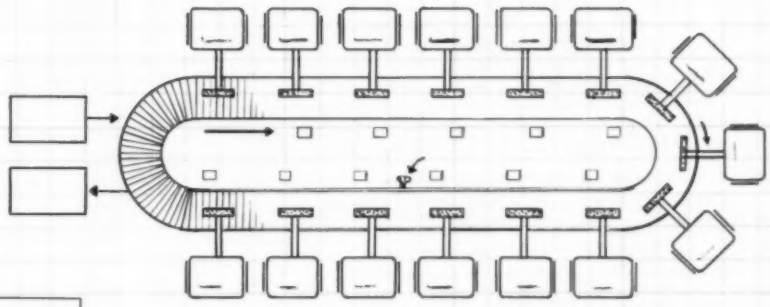


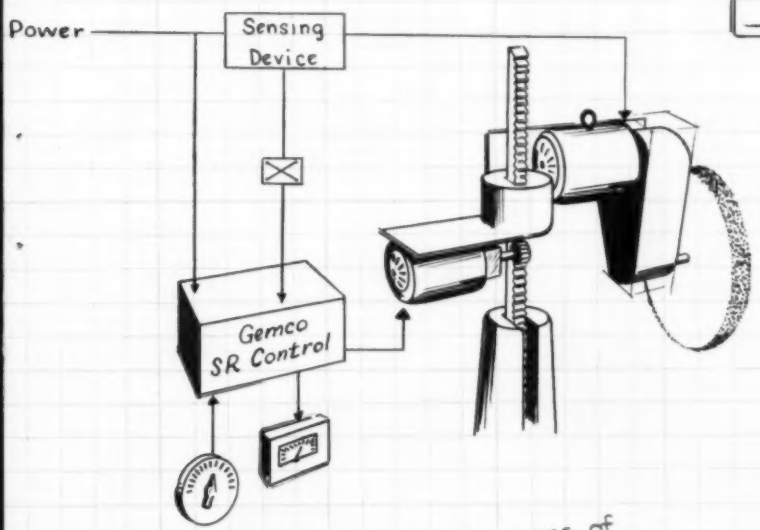
The operator of this Gemco console can pre-set the optimum load on any of 12 polishing spindles and be sure it is maintained. A separate panel holds all necessary switchgear.

GEMCO SR* HOLDS PRE-SET LOAD

(1) A continuous conveyor feeds clamped parts to each spindle.

(2) Optimum polishing power is pre-set with *Gemco saturable reactor control for each spindle.





(3) Once during each conveyor cycle, a switch dog mounted on the conveyor, cuts a sensing circuit into each spindle motor input.

(4) If buffer wear has caused power drop, the saturable reactor feed-back circuit energizes the spindle feed motor.

(5) When optimum spindle power is again reached, down feed stops.

(6) Gemco's 12 years of specialized automatic control experience may solve your problem. Call, wire or write.

Circle 697 on Page 17

GEMCO
CUSTOM CONTROLS
GEMCO ELECTRIC COMPANY
25681 W. 8 Mile Rd. • Detroit 40, Mich.

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Whatever your heating job may be, you'll find the efficient, economical answer in . . .

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. . . for heating platens, dies, molds, metal parts . . . for heating liquids, air, gases . . . for curing, drying, baking . . . for comfort heating in offices and factories . . . for special applications . . . in fact for any application requiring fast, low-cost, controlled heat up to 1100°F.

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from the world's largest factory stock of industrial electric heaters . . . over 15,000 types, sizes and ratings.

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Write for your copy of Catalog 50

Contains helpful information on design uses, and prices of Chromalox Electric heaters, elements, thermostats, contactors and switches.

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☐ A copy of "101 Ways"
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Company _____

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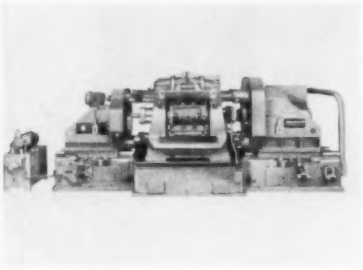
A-4455A

Circle 698 on Page 17

and the processing is complete. Production rate is 150 distributor bases per hour. **Ex-Cell-O Corp.**, 1200 Oakman Blvd., Detroit 32, Mich.

Circle 417 on Page 17



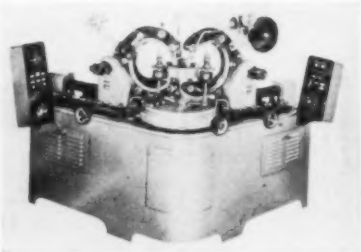
Crankshaft Processor

Item 418

Six-station, two-way trunnion machine is designed so four different crankshafts can be processed without the need of fixture detail and tooling changes. It can produce 64 crankshafts per hour. Cluster heads with individual bushing plates are incorporated in a master gear box.

In operation, the left hand head drills, countersinks, counterbores, spotfaces, and taps one hole in the front end of the crankshaft. The right hand head drills, countersinks, and reams eight bolt holes; drills, counterbores, and countersinks one hole in rear end of crankshaft. The eight boltholes are held concentric with the outside diameter of the rear end flange by piloting the bushing plate on the flange of the workpiece. **Buhr Machine Tool Co.**, Ann Arbor, Mich.

Circle 418 on Page 17



Winding/Taping Machine

Item 419

Device features simultaneous, separate, or sequential winding of

CHROMALOX

electric cartridge heaters

POSITIVE LEAD WIRE PROTECTION
FOR STANDARD AND HI-WATTAGE MODELS

New special features help Chromalox electric Cartridge Heaters provide longer life and more dependable spot heat. Use where abrasion or steam, oils or moisture limit heater life.

New high strength spring guard protects against stress and vibration. Moisture-resistant flexible brass conduit provides rugged, vapor-tight, drip-proof cover for lead wires.

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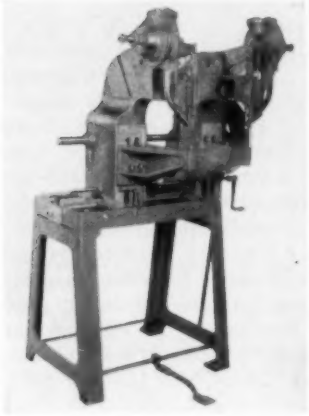
7850 Thomas Boulevard • Pittsburgh 8, Pa.

CHROMALOX — FIRST NAME IN ELECTRIC HEAT

Circle 699 on Page 17

wire and tape. It is capable of producing medium, large, and extra large toroidal coils. Machine is equipped with a core-turning table, an automatic *forward* and *reverse* feed, a stepless variable pitch control, calibrated adjustable twin tension brakes, a quick-locking shuttle gear and magazine, an automatic predetermining counter, a tape footage indicator, and an automatic cutoff. Two models with different wire diameter ranges are available. **Universal Mfg. Co. Inc.,** 410 Hillside Ave., Hillside, N. J.

Circle 419 on Page 17



Double Drive Riveter

Item 420

Unit is suitable for riveting electrical chassis and equipment, automotive parts and accessories, and electrical appliances. Machine automatically feeds and sets at the same time, two rivets up to 0.200 inch in diameter. The rivets can be of different lengths and head diameter specifications. Model 109 has a 12-inch throat and center distances adjust from ⅝-inch to 16-inches by hand crank. A trip mechanism actuates the machine, and a non-repeat, single revolution clutch operates it.

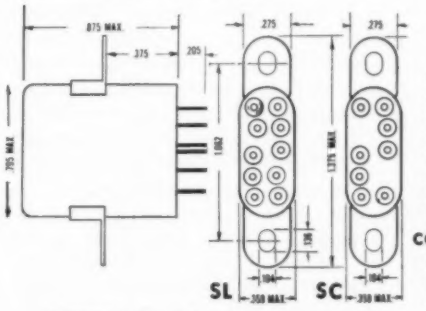
Riveter can be furnished as a bench model when equipped with a solenoid trip, or it can be supplied with air operation for fastening fragile ceramic parts. It can be used in combination with company's basic machines to make up a multi-head riveter. **Tubulat Rivet & Stud Co.,** Wollaston (Quincy) 70, Mass.

Circle 420 on Page 17

CRYSTAL-CASE SIZE! PERMANENT MAGNET DESIGN.
SHOCK: 100g. VIBRATION: 30g 55 TO 2000cps. NO CONTACT OPENINGS.

SC NON-LATCHING TYPE—This micro-miniature relay sets new standards —in design, in performance, in reliability. Yet the SC conforms to standard dimensions and circuitry and may be used to replace ordinary crystal-case relays. A permanent magnet in the structure provides *at least twice the contact pressure found in relays of comparable size.*

SL LATCHING TYPE—Unique magnetic latch assures exceptional contact pressure. A 1 watt, 3 ms. pulse to either coil transfers contacts. Transfer time is only 0.5 ms. Has the same exceptional shock and vibration characteristics as the SC.



SC and SL Series Engineering Data

Operate Time: 3 MS. max. with 550 ohm coil @ 24 V. DC. (SL: 630 ohm coil at 24 V. DC).
Transfer Time: 0.5 MS max.
Terminals: (1) Plug-in for microminiature receptacle of printed circuit board. (2) Hook end solder for one #20 AWG wire.
Enclosure: Hermetically sealed.
CONTACTS: Arrangement: 2 Form C.
Material: Gold flashed palladium.
Load: 2 amps @ 28 V. DC, resistive; 1 amp @ 115.V. AC, resistive.
Pressure: SC—13 grams min.; SL—16 grams min.
COIL: Power: Approx. 1.0 watt at Nominal Voltage.
Resistance: SL—40 to 1400 ohms; SC—35 to 1250 ohms.
Duty: Continuous.
MOUNTINGS: Bracket, stud and plug-in.

GENERAL: Insulation Resistance: 10,000 megohms, min.
Breakdown Voltage: 1,000 V. RMS.
Shock: 100g.
Vibration: 30g 55 to 2000 cps.; 0.195" max. excursions from 10-55 cps.
Temperature Range: -65°C. to +125° C.
Weight: 17.5 grams (5/8 oz.).

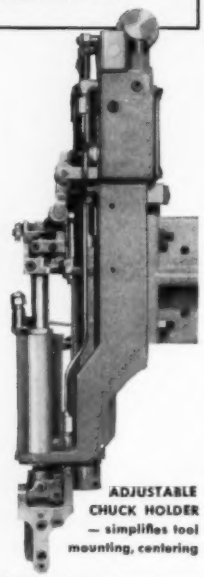
P&B Standard Relays are available at your local electronic, electrical and refrigeration distributors

Potter & Brumfield, inc.

PRINCETON, INDIANA · SUBSIDIARY OF AMERICAN MACHINE & FOUNDRY COMPANY
Manufacturing Divisions also in Franklin, Ky. and Laconia, N.H.

Circle 700 on Page 17

SAVE TIME
AUTOMATING
SMALL PARTS
ASSEMBLY
OPERATIONS
SPECIFY
DIXON
"Auto-Positioner"



FITS IN SMALL SPACE—21" X 3¼" X 5" DEEP

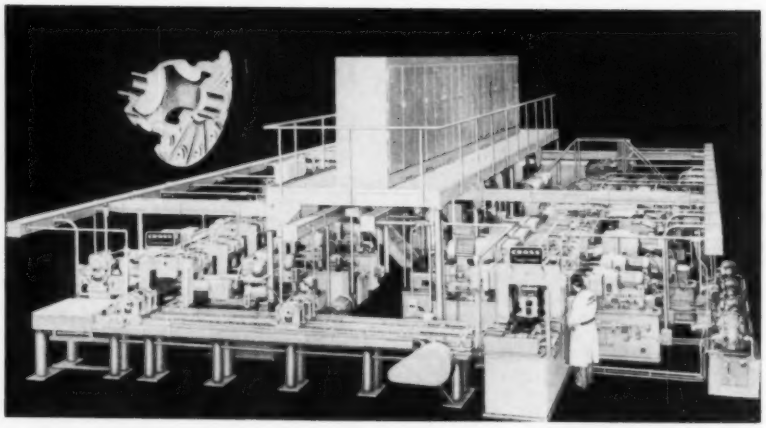
ADJUSTABLE CHUCK HOLDER — simplifies tool mounting, centering

- **STANDARD HEAD DESIGN**—Saves engineering time. Easy to apply to variety of jobs. Operates on ordinary 80# air pressure, 110 volts. Has machined T-slot surface, simple adjustments. Tooling, mounting column, feeders, etc., optional.
- **BUILT-IN SENSING**—Acts as automatic inspector, assures quality production. Machine stops if part is missing or malformed.
- **FAST, VERSATILE**—Handles wide range of feedable metal or plastic parts from ⅛" to 3" O.D. at speeds up to 100 cycles per minute. Easy to tool.
- **PRECISION-BUILT**—Sturdy frame, one-piece super-finished piston and rod, cushioned air cylinder, J.I.C. controls.
- **WRITE FOR FULL DATA**—New circular gives complete specifications, shows typical applications.

DIXON PARTS ESCAPEMENTS
Releases single parts or in multiples at speeds up to 200 per minute. Standard models available for air, solenoid, or mechanical operation.

DIXON AUTOMATIC TOOL, Inc.
2312–23 rd AVENUE
ROCKFORD, ILLINOIS
Equipment for Automatic Parts Handling and Assembly

Circle 701 on Page 17



Gear Case Machining and Inspecting Unit

Item 421

Machine can produce one-piece rear axle differential gear cases. Machining two parts at a time, unit rough and finish forms the two spherical seats for the pinions, rough and finish bores and faces the two seats for the side gears, drills, bores, and reams the pinion shaft hole, drills and reams the lock pin hole, and drills, chamfers, spotfaces, and reams 12 ring gear mounting holes. Production rate is 212 pieces per hour.

Gear cases are transferred through the machine on pallet-type work holding fixtures. Part location in the pallet fixtures is from the ring gear seat and one of the two end bearing diameters, which are turned and ground in previous operations. Movement from station to station is done with two reciprocating transfer bars. At the forward end of the transfer stroke, elevators lift the pallets from the transfer bars into engagement with fixed locating pins and rest buttons, which are attached to overhead bridge structures. Wedges then back up the elevators to secure the pallet fixtures in final position. Overhead bridges also carry the cutters in stations where internal boring and facing operations are performed. As the pallets are elevated to the clamped position, the cutters enter the part through the casting window, and find their correct location relative to the gear case.

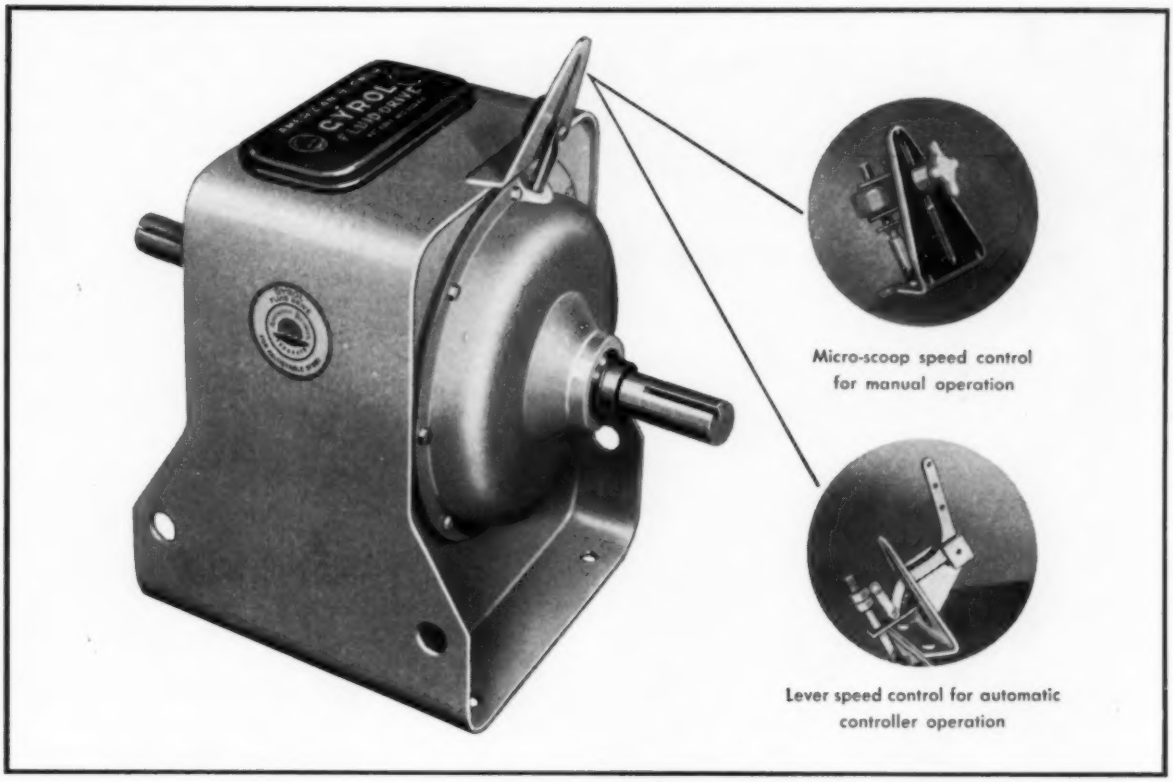
Sequence of operations in the machine is as follows: Two parts are loaded in twin fixtures in Station 1; side gear pockets and thrust faces are rough and finish formed in Stations 2, 3, 4, 5, and 6; parts are washed in Station 7; side gear pockets are inspected in Station 8; clearance is milled for the locking pin hole drill bushing in Station 9; pallets are indexed 90 degrees in Station 10; pinion shaft hole is drilled, chamfered, and semifinish bored in Stations 11, 12, and 13. Stations 14 and 15 are set aside for visual inspection; the pallets are indexed 90 degrees in Station 16; the ring gear holes are drilled, chamfered, spotfaced, and reamed, and the lock pin hole is drilled and reamed in Stations 17, 18, 19, and 20; the pallets are indexed 90 degrees in Station 21; the spherical seats are rough and finish milled in Stations 22 and 23; pinion shaft hole is finish line-reamed in Station 24; the parts are washed in Station 25, spherical seats are gaged in Station 26; pallets are indexed 90 degrees in Station 27, the finished gear cases are removed from the pallet fixtures in Station 28, pallet fixtures are washed in Stations 29 and 30 in preparation for the loading operations. **Cross Co.**, 17801 Fourteen Mile Rd., Detroit, Mich.

Circle 421 on Page 17

Packaged Conveyor Unit

Item 422

Prepackaged unit consists of separate drive, take-up, and inter-



Micro-scoop speed control for manual operation

Lever speed control for automatic controller operation

American Blower *Gýrol*® Fluid Drives now available in lower horsepower ranges!

Type VS, Class 2 Gýrol Fluid Drives for 1- to 25-hp applications. Also available with flange-mounted motor, as shown.

Adaptable to either automatic or manual control, American Blower Type VS, Class 2 Gýrol Fluid Drives come in a complete range of new smaller sizes—1 hp to 25 hp, speeds to 3600 rpm—to satisfy your every power-transmission need!

These compact, self-contained units offer an answer to many industrial-drive problems because of their important benefits: adjustable, stepless speed control; full reversibility; 5 to 1 speed range; no-load starting; protection against shock; quiet operation.

For full information on the complete line of Type VS, Class 2 Gýrol Fluid Drives, 1-800 hp—or other designs to 12,000 hp—contact our nearest branch office. Or write: American Blower Division of American-Standard, Detroit 32, Michigan. In Canada: Canadian Sirocco products, Windsor, Ontario.

AMERICAN BLOWER

Division of AMERICAN-Standard

Circle 702 on Page 17

T-J spacemaker cylinder

Quality Engineered

to give quality results

with Extras . . .
at No Extra Cost!

You get more—much more—when you specify and use any of T-J's complete line of Spacemaker cylinders. The Spacemaker is engineered to give you better, more accurate, and longer service—offers, exclusively, many extras . . . that are STANDARD, AT NO EXTRA COST!

Designed to eliminate tie-rods, providing greater strength . . . saves space . . . reduces manhours and costs in all push-pull-lift operations. OFF SHELF DELIVERY in a wide range of styles and capacities, with 64,000 combinations. Write for catalog SM 56-2 with complete engineering details. The Tomkins-Johnson Co., Jackson, Mich.

METAL PISTON ROD SCRAPER . . . Standard at No Extra Cost!

NEW "SUPER" CUSHION FOR AIR . . . Standard at No Extra Cost!

CHROME PLATED CYLINDER BORES AND PISTON RODS . . . Standard at No Extra Cost!

ONE PIECE PISTON . . . Standard at No Extra Cost!

NEW "SELF-ALIGNING" MASTER CUSHION FOR HYDRAULIC USE . . . Standard at No Extra Cost!

NO TIE-RODS TO STRETCH . . . Standard at No Extra Cost!

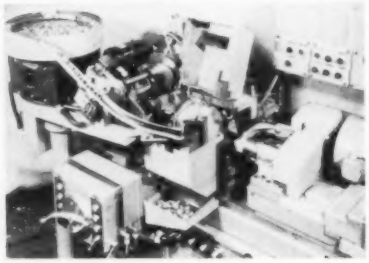
STREAMLINED DESIGN . . . Oil Pressure to 750 P.S.I.—air to 200 P.S.I. Standard at No Extra Cost!

FORGED SOLID STEEL HEADS . . . Standard at No Extra Cost!

T-J TOMKINS-JOHNSON
RIVETERS, AIR AND HYDRAULIC CYLINDERS, CUTTERS, CLINCHERS

mediate bed sections which can easily be assembled in a variety of combinations. Additional bed sections and belting are available when enlarging is required. Conveyors are available in 5 to 100 foot lengths for stationary operation and 5 to 25 foot for portable use. Units have 6 through 30 inch belt widths, ⅓ through 1 hp motors for fixed or variable speeds, and are available with belt trough or side leaves. **Arrow Products Inc.**, South Ferry St., Grand Haven, Mich.

Circle 422 on Page 17



Grinding Machine

Item 423

Device automatically bores and face grinds trunnion bearings at rate of 162 parts per hour. Trunnion bearings are dumped into a vibrating hopper and fed out of the bowl and along a track to the loading chute. The advance of the parts in the hopper is controlled by a rheostat to coincide with the machine cycle. Improperly oriented parts are automatically pushed off the track and back into the bowl. An automatic shutdown switch in the loading chute gives positive backup protection against improperly oriented work reaching the loading station.

A loading arm automatically picks the work out of the chute and inserts it into a toggle clamp fixture in the workhead. The workhead positioning device stops the head in proper position to accept the work. After clamping, the loading arm returns to starting position and the grinding cycle begins. The face of the wheel is fed into the work and plunge bore grinding begins at the same time. Face grinding is completed first, stopping all action in the facing feed box. Bore grinding continues until the dress point is reached. Wheel is then dressed and finish

Circle 703 on Page 17

plunge grinding is completed. **Heald Machine Co.**, Worcester 6, Mass.

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Parts Feeder

Item 424

Unit feeds 2 inch by 3½ inch slugs from an integral hopper into a heat-treating machine at a predetermined speed. Angle of elevation, depth of cleats and machine speed can be adjusted to adapt unit to feed rolling or sliding parts into a broad range of high-speed production machines. Model 2500 is self-contained, powered by a ½ hp, 3 phase 220/440v motor, has a 42⅜ inch loading height, and automatic shut-off controls. **Feedall, Inc.**, Willoughby, Ohio

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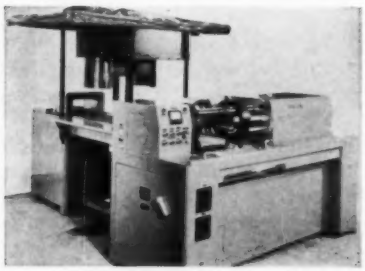
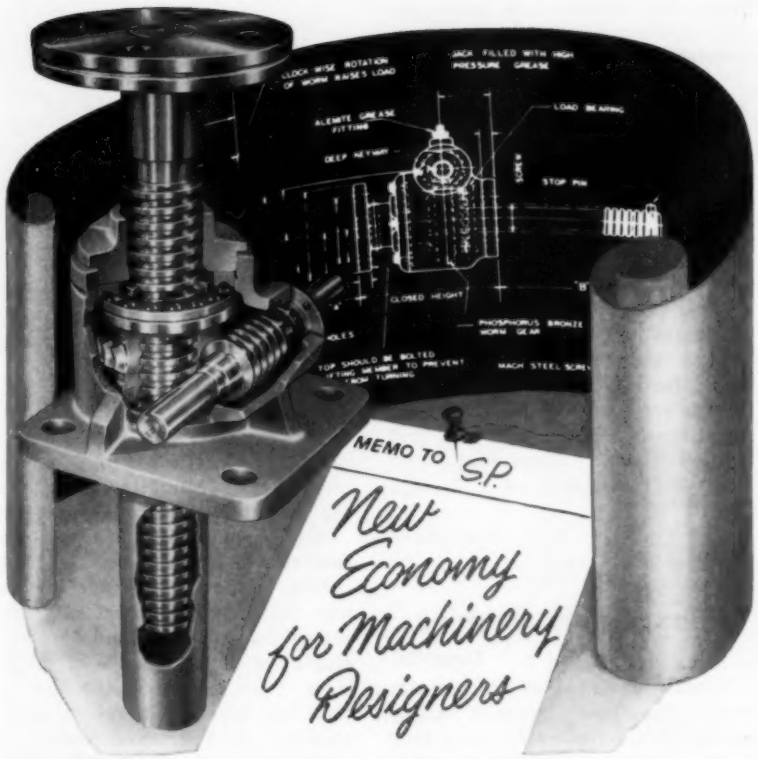


Inspection Unit

Item 425

Machine is capable of handling a wide variety of small steel and iron parts. Water bath materials are used with fluorescent magnetic particle inspection. Magnetization can be circular and longitudinal, simultaneous or separate for the detection of both longitudinal and



NOW, A STANDARD LINE OF DUFF-NORTON WORM GEAR JACKS

The economies of standardized production now can be realized by machinery designers who use Duff-Norton worm gear jacks for accurate positioning of loads weighing as much as several hundred tons. After 25 years of experience and hundreds of custom designs, Duff-Norton engineers have produced a standard line of eight jacks ranging from 2 to 100 tons in capacity which will meet almost any requirements. When jacks are used in an arrangement, added economy can be realized in raising unevenly distributed loads, since all models now have a uniform raise which permits jacks of varying capacities to operate in unison.

Worm gear jacks are purely mechanical devices, and they can hold heavy loads in position indefinitely without any creep. Functioning as components of machinery or equipment, they can raise or lower loads, apply pressure or resist impact. Worm gear jacks can be furnished with raises up to 24 inches, and they will provide exactly the same raise for years without adjustment.

Thousands of these jacks are in use on feeding tables, tube mills, welding positioners, pipe cut-off and threading machines, testing equipment, aircraft jigs, loading platforms, rolling mills, conveyor lines, and numerous other types of equipment. If you have a positioning problem, write for complete information, requesting Bulletin AD-66-GG, which includes drawings and full specifications.

DUFF-NORTON COMPANY

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COFFING HOIST DIVISION • Danville, Illinois

DUFF-NORTON JACKS
Ratchet, Screw,
Hydraulic, Worm Gear

DUFF-NORTON

COFFING HOISTS
Ratchet Lever
Spur Gear, Electric

Circle 704 on Page 17

transverse defects. A conveyorized unit can be added to speed up the inspection operation.

Company also has line of electronic testing instruments which includes a conductivity meter for measuring hardness, purity, sorting mixed nonmagnetic metals, and determining uniformity of heat treat; an ultrasonic instrument for thickness measuring; an electronic crack detector designed to find defects in spark plug ports of aluminum aircraft cylinders; and a unit which automatically evaluates and sorts magnetic materials for alloy composition, heat treat condition, depth of case, and carbon content. **Magnaflux Corp.**, 7300 W. Lawrence Ave., Chicago 31, Ill.

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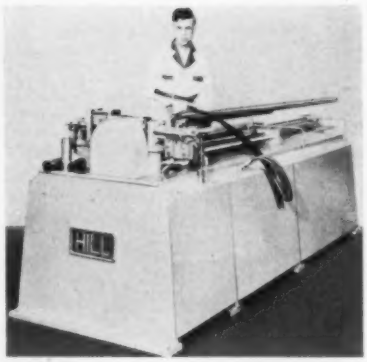
Tubing Cutoff Machine

Item 426

Unit is designed to produce accurate, burr-free lengths of tubing at high production rates. Burr-free cutting of parts on the machine is aided by clamping the tubing



rigidly on each side of the cut to avoid the formation of hanging burrs at the saw breakthrough point. The saw is fed in a straight line by a hydraulic cylinder, holding saw deflection to a minimum.

Adjustments are provided for feed rate of saw and feed length of tubing. Clamps are interchangeable, and up to eight different tube diameters can be handled by a single set of clamps. For smaller sizes, four different diameters of tube can be cut without changing clamps. In operation, tubing is advanced to the feed clamp and the *Cycle* button is pressed. The feed clamp grips the tube and advances the portion to be cut off into a second hydraulic clamp which grips the tube on each side of the saw cut. The previously cut-off piece is ejected from the machine at the same time that the tube is advanced. The saw next advances and cuts off the tubing length. Saw feed is adjustable by flow control of its hydraulic feed cylinder. During the cutoff operation, the feed clamp retracts automatically and grips the tube. The tubing is automatically advanced for another cut as soon as the saw completes the cutoff operation and returns to its starting position. **Walter P. Hill Inc.**, 22183 Telegraph Rd., Detroit 19, Mich.

Circle 426 on Page 17

Users of Adjustable Drill Heads are unusually accurate in anticipating profit pictures —they regularly figure lower and *more dependable costs.* That's because these high-quality heads—priced right to start with—usually cost less to maintain, less to operate.

The U-1 Head shown has 8 drivers, ¼" drilling capacity in cast iron, 6" diameter drilling area. With 2 spindles and Erickson chucks, it costs only $260.

And that's because ALL U. S. Heads of this type have these plus features:

SHAVED GEARS
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Adjustable and Fixed Center Multiple Drilling Heads
Individual Lead Screw Multiple Tapping Heads

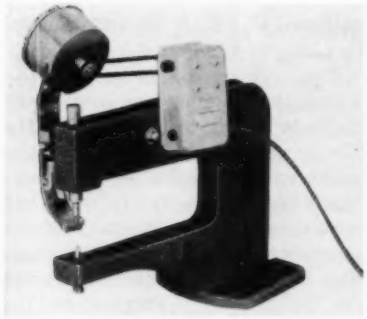
UNITED STATES DRILL HEAD CO.
BURNS STREET • CINCINNATI 4, OHIO

Semiautomatic Speeder

Item 427

Machine is capable of high-speed testing of cut-off saws, cup and grinding wheels. Accurate speed selection, automatic cycling, and centralized controls are features of the unit. The operating cycle is started by pushing two-hand starting buttons. The wheel is elevated and a safety cover closes. Wheel is clamped to turntable and accelerates to preset speed, decelerates and stops. Wheel then lowers to unloading position. Speeds up to 15,000 rpm are possible. Mechanical components are dust tight with totally enclosed motor and hydraulic drive. All bearings are antifriction, pre-lubricated and sealed. **George L. Day Co. Inc.**, 1227-1231 Niagara St., Buffalo 13.

Circle 427 on Page 17



Eyelet Machine

Item 428

Unit has a motor-driven electrical feed, is suitable for eyeletting novelties, leather, cloth, and paper products. It also handles printed circuit boards. Model AE-100 has a belt-driven agitator built into the hopper which automatically feeds the eyelets from slots in the hopper into the track and down to the work position. Machine has an 11-inch throat depth and a high overhanging arm for easy handling of large workpieces. Tracks are interchangeable and the unit can handle all common sizes of eyelets up to $\frac{3}{8}$-inch in diameter. **Eyelet Tool Co. Inc.,** 236A Broadway, Cambridge, Mass.

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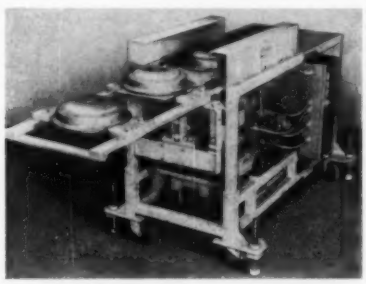

Feeder/Unloader Unit

Item 429

Device is a combination transfer feeding and unloading unit capable of handling stampings in pressrooms. The unit can be used to load and unload one press, or it can be placed in a line of presses with a continuous transfer bar to provide a completely automated transfer line. A lift mechanism operates in a vertical direction under the controls of close-fitted guide bars, enabling parts to be placed over gage pins for proper accuracy

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Circle 706 on Page 17

Difficult batching problems solved by Autoweightion*

- *All types and combinations of materials successfully handled*
- *High degree of accuracy obtainable*
- *Thayer Scale Flexure Plate Leverage System guaranteed accurate for life*

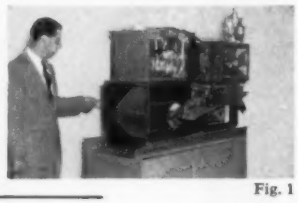

Fig. 1

The development of the Thayer Autoweightion System for controlling materials processing systems has opened the door for many hitherto impractical batching operations. For instance, several different flushing materials (flooding powders) can now be handled without leakage by a tipping bucket weigh hopper (Fig. 1) controlled by a series of different range Thayer weigh beams.

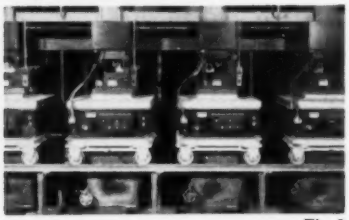

Fig. 2

Thayer individual batching scales can be used to furnish preweighed charges which may be varied in weight to suit the formula. The system shown (Fig. 2) can be furnished to allow positioning under various bins or feeders so each scale will preweigh a given weight charge and discharge it to a conveyor belt or to a mixer for further processing.

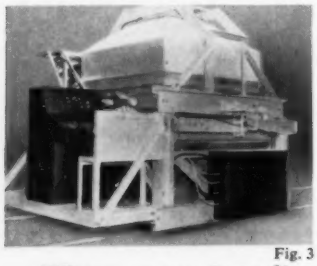

Fig. 3

Where many ingredients are to be handled and there is a factor of space saving and a minimum amount of equipment, it is possible to utilize an accumulative batching scale which can either be fixed or moveable as shown (Fig. 3). This unit will have a large weigh hopper sufficient to accommodate the total weight of any number of ingredients desired to be accumulated. To secure accuracy in various weight ranges, the weighing of each individual ingredient will be controlled by its own weigh beam on the scale and the various ingredients will be weighed into the common weigh hopper in turn at the prescribed formulated weight.

Difficult to handle materials, such as hot tar, high viscosity liquids and other such ingredients which leave a residue in the weighing vessel can be handled in a loss-in-weight manner by first precharging a vessel to any weight and then withdrawing a known amount for the desired charge (Fig. 4). By this means the remaining tare weight within the hopper will not affect the weight of the next discharged load. Such a unit can be used either as a single batching scale or as an accumulative batching scale discharging in a loss-in-weight manner.

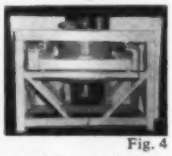

Fig. 4

Engineered solutions such as these have put Thayer batching systems into many of the best known processing plants in North America. Thayer builds a complete line of feeders interlocked with Thayer Scales. Remote controls, adding machines and chart indicators are also supplied. Please write us about your batching problems.

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THAYER SCALE CORP.
5 Thayer Park, Pembroke, Massachusetts

of location. Both lift and transfer motions have adjustable strokes.

Two air-operated, electrically-controlled air cylinders control the motions of the transfer bar in the feeder and unloader. One cylinder raises and lowers the bar assembly; the other controls the forward and reverse motions. In operation, a stamping to be fed into the press dies is placed in a preload station on the feeder. Fingers on the transfer bar pick up the part as the bar is lifted, and deposit it in an intermediate station as the part is carried forward and lowered by the lift and carry mechanism. The number of intermediate stations in the feeder unit depends on the press spacing. On the next sequence of the transfer bar, the stamping is lifted from the intermediate position, advanced, and lowered into the die over gage pins. When the press has completed its cycle, unloading fingers on the transfer bar pick up the finished stamping and advance it to the next operation while another part is being loaded into the die. **Press Automation Systems Inc.,** 25418 Ryan Rd., Centerline, Mich.

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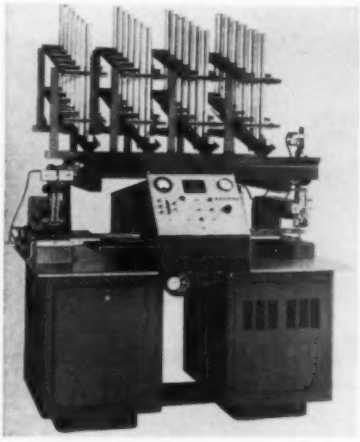

Circuit Board Machine

Item 430

Tape-controlled device automatically positions circuit boards, drills holes, selects components, and inserts components in proper sequence. By changing the tape, a new sequence of motions is produced. Information from punched-tape is translated into automatic

drill-positions. The device selects components of up to 24 different values from conveying chutes, interprets information from punched tape, and readies components for insertion. Each component is inserted in proper sequence. Eyelets and terminal pins are assembled securely. **Electro-Machinery Div., Design Tool Corp.,** 80 Washington St., New York 6, N. Y.

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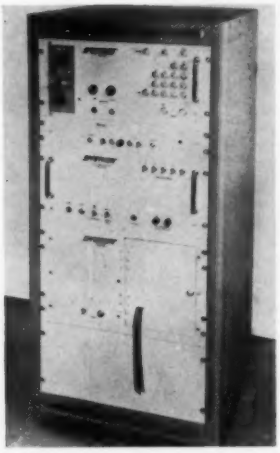

Data Processor

Item 431

Instrument converts analog information to digital form, either visually as a direct reading in-line numerical 3 digit indication, as a number printed sequentially on paper tape, or in punched tape form. The punched tape form is convenient as it can be used to reproduce the data on an electric typewriter, on a punched card, or for entry directly into a digital computer. Pressure, temperature, force, rate, acceleration, or any other variable that can be presented as an analog voltage can be used as input information.

A ten-line code per digit is available to drive a variety of other devices. Models range from simple single channel, single output equipment to versatile multichannel devices with output in several selectable forms. Smaller units are completely portable, and the larger equipment is mounted on rubber tired wheels for roll around in-plant use. **Systron Corp.,** 2055 Concord Blvd., Concord, Calif.

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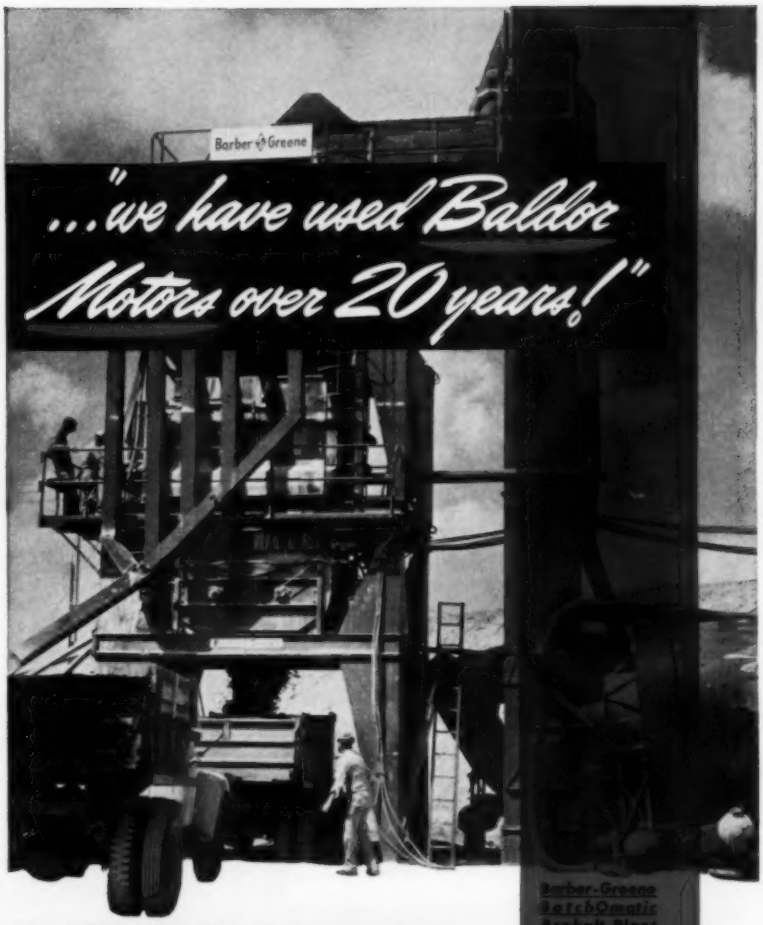

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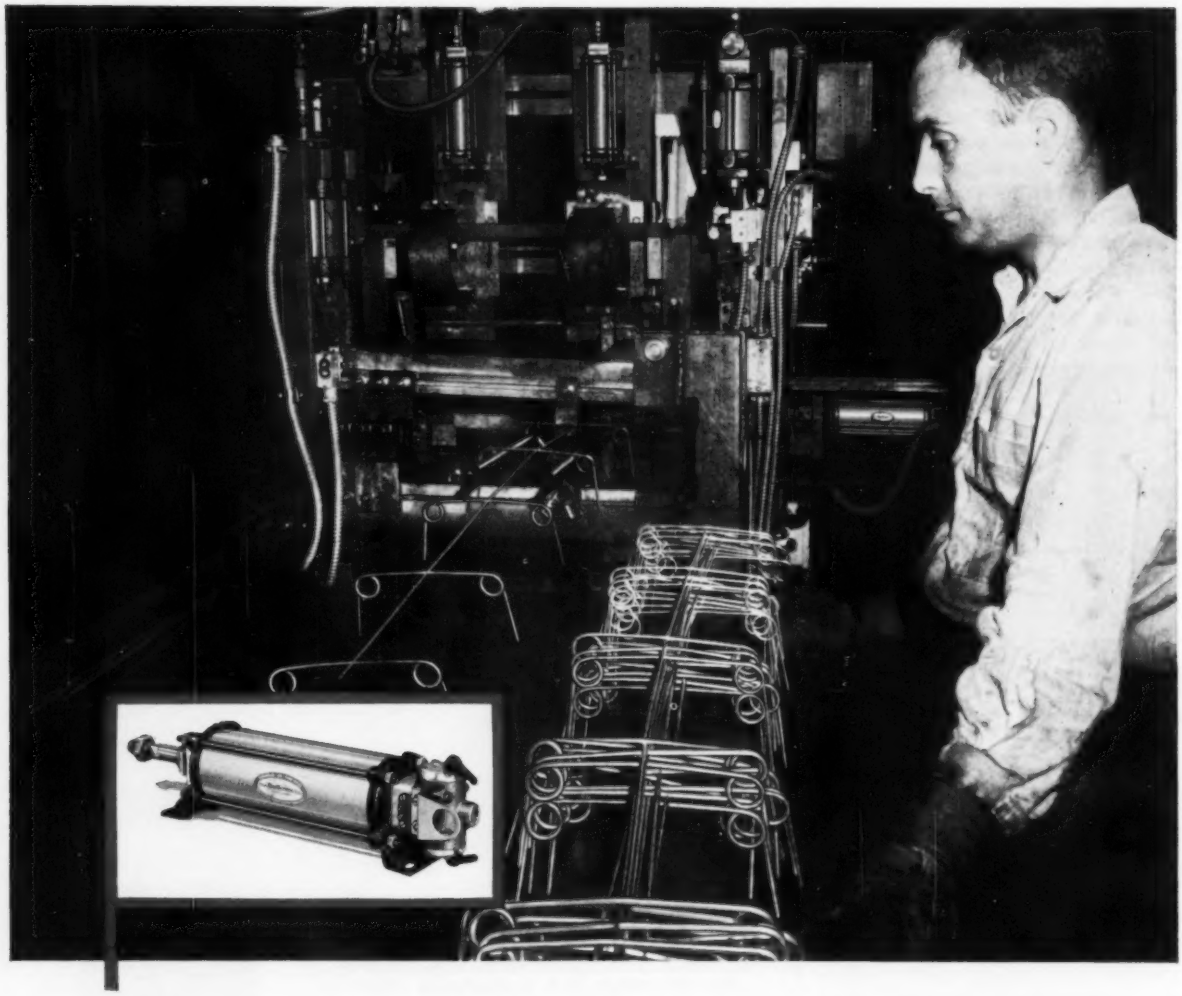
Circle 708 on Page 17



THE BELLOWS AIR MOTOR PUTS PRACTICAL AUTOMATION WITHIN REACH OF EVERY PLANT IN EVERY INDUSTRY

Regardless what you make, The Bellows Air Motor can spark cost-saving ideas in the minds of your methods engineers who are looking for practical ways to put automation to work.

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The wire reinforcement shown above is an old product. Many companies had made it by hand without change for over 40 years. But Conver Steel & Wire Co., New York, had an idea.

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Would you like to see a file of cost cutting ideas other companies have developed using Bellows Air Motors? Write Dept. AU-258, The Bellows Co., Akron 9, Ohio.

In Canada: Bellows Pneumatic Devices of Canada, Lt., Toronto 18.

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DIVISION INTERNATIONAL BASIC ECONOMY CORPORATION

AKRON 9, OHIO

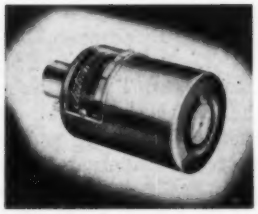
1031-B

Circle 709 on Page 17

AUTOMATION new components

Parts, elements and devices designed for creating more automatic systems

For detailed information and literature, use card page 17.



Proximity Detector

Item 432

Unit is designed for sorting and counting, responds to the presence of all metallic and most nonmetallic materials. Model 6120 can also be used for limiting, warning, and gaging when used with company's controller, Model 6330. Response rate is 400 ppm; output is nominally 5 v dc across a 5 megohm load. Within limits, the unit can detect a 1/16-inch change of position of metallic parts. **Autron Engineering Inc.**, 1254 W. Sixth St., Los Angeles 17, Calif.

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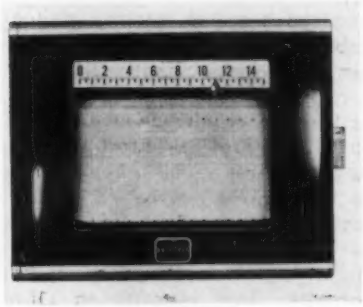

Curve Plotter

Item 433

Instrument can automatically plot a continuous curve showing the relationship of one measured variable to another. Applications include plotting temperature versus pressure in the process industries, position of intake parts versus gas flow in wind tunnel research, location on web versus thickness in paper making, and speed versus torque in motor operation. Device records on a 12-inch strip chart, is available with pen speeds of up to 0.4 second for full scale traverse to follow rapidly changing variable. Accuracy is 0.25 per cent. **Bristol Co.**, Waterbury 20, Conn.

Circle 433 on Page 17

Pressure Transmitter

Item 434

Instrument is capable of measuring pressures as high as 250 psi or ranges from as low as zero to 100 inches of water. System operates on the force-balance principle. Model P-06 transmits a linear 3-15 psi signal to a recorder, indicating gage, or manometer. It can be mounted horizontally or vertically on both open and closed tanks. No dip tubes, floats, or other mechanical devices are required inside the vessel. Transmitter is designed to eliminate the possibility of measured material backing up into air lines in the event of pressure diaphragm rupture. **Conoflow Corp.**, 2100 Arch St., Philadelphia 3, Pa.

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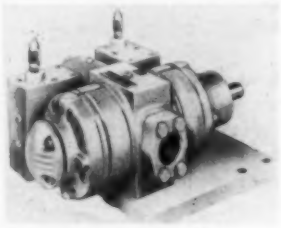

Double Pump

Item 435

Suitable as a hydraulic pump and lubricating oil pump on machine tool applications, device consists of two 2000 psi cartridges mounted in one assembly. The heavy bearing construction absorbs radical hydraulic and shock loadings, and the cartridge plates permit quick field changes of capacities to meet requirements. Capacities of each cartridge section range from 3 to 18 gpm or any combination of these volumes. Pumps can have a common outlet or separate outlets to separate circuits.

For automatic operation on a two-pressure common outlet circuit, deliveries of both pumps are combined until the pressure approaches setting of unloading valve. The large pump then discharges to the tank at no pressure while the small pump continues to furnish oil to circuit until pressure setting of integral relief valve is reached. **Geroter May Corp.**, Owings Mills, Md.

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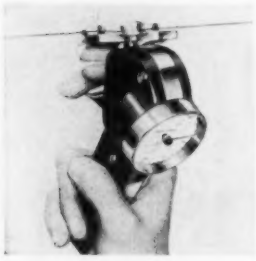

Tension Measurer

Item 436

Device features low deflection and negligible wire contraction while measuring tension during wire processing. Trigger of the meter is pulled in the same manner in which a gun is cocked. This opens the 3-roller mechanism for quick wire insertion. The wire is then placed on the two lower rollers which are recessed into the plate. When the trigger is released, the wire automatically slips into the pulley grooves, minimizing wire breaks and bending of the wire between the rollers. The center roller deflects against the restraint of a special calibrating spring. The distance the center roller is lifted is a fraction of an inch, but this motion is mechanically amplified over a precise gage movement. The tension of the material is clearly seen on a dial while the wire runs. **Tensitron Inc.**, Harvard, Mass.

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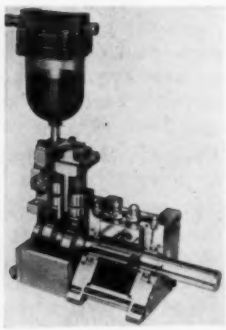

Motor & Speed Control

Item 437

Line of hydraulically-actuated oscillating motors can be mounted on any of five sides. The self-contained hydraulic speed control has cushions for air applications. The lapping action of the oscillating shaft is resisted by the use of ball bearings. The units have 37 degree straight thread O-ring seal tube fittings and double end shafts. **Tork-Mor Inc.**, 4845 Bellevue, Detroit 7, Mich.

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Remote Preset Counter

Item 438

Applicable for batching, sorting, packaging, counting, controlling, and frequency division, counter is designed so selected numbers can be preset from a remote position. Model 101AR is controlled by use of a five-wire cable brought out the back of the unit and terminating in a small five-pin plug.

The cable can be extended to any reasonable distance and a simple switch at the extremity is used to select any digit from zero to 9. The actuating voltage can be from 6 to 24v dc. Unit provides an output pulse at a selected number of rates in excess of 40,000 counts per second. If reset is not required, the unit is capable of counting 100,000 counts per second. **Computer Measurements Corp.**, 5525 Vineland Ave., N. Hollywood, Calif.

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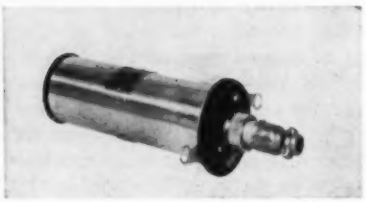


Radiation Pyrometer

Item 439

Device measures the temperature of hot objects without touching them, is suitable for use where corrosion or other conditions prevent the use of conventional resistance-type temperature detectors. Radiation from the hot object is focused on a small aperture in front of a thermopile which consists of a bank of ten thermocouples connected in series. A variety of lenses, depending on the use, is employed to focus the radiation on the thermopile. Ninety-eight per cent of full reading is obtained in two seconds.

Instruments are available for ranges between 1000 and 3300 F. Two protective air purge fittings are available. The first fitting projects a beam of air along the line of focus to prevent dust and fumes from obscuring the screen or lens. The second is used with closed end sighting tubes and permits the escape of air from inside the housing, thereby protecting the lens from condensate. **Instrument Div., Robertshaw - Fulton Controls Co.**, 2920 N. Fourth St., Philadelphia 33, Pa.

Circle 439 on Page 17

Electronic Relay

Item 440

Device is capable of controlling large amounts of power. Model 4 employs a sealed mercury switch tube which is tilted to the open-circuit or closed-circuit position by a magnetic circuit, giving positive action, and requiring less dc power. Relay provides direct current in the control circuit. Lead wires to the control can be very long, since device is independent of capacitance changes. The control circuit operates on microampere currents. Unit operates on 115v ac. Control voltage is 7v dc open circuit. Control current is 1.5 microamps dc closed circuit. **Manostat Corp.**, 20-26 N. Moore St., New York 13, N. Y.

Circle 440 on Page 17

ACTUATE

MORE EASILY... EFFICIENTLY... ECONOMICALLY

ROLLED THREAD

SAGINAW b/b SCREWS

Make Your Product

- easier to produce
- easier to operate
- easier to sell

The secret lies in a new anti-friction principle—steel balls recirculating in closed-circuit raceways. They permit Saginaw b/b Screws to change rotary motion into linear motion with over 90% efficiency and 4/5 less torque than Acme screws. Result: Saginaw b/b Screws save manual effort or electrical power; they permit space savings—smaller motors and gear boxes; they provide more dependable performance; more precise positioning; more temperature tolerance and more lubrication latitude.

SEVEN STANDARD SIZES REDUCE COSTS

Top-quality Saginaw b/b Screws are the only kind stocked in seven standard commercial rolled thread sizes, cut to desired length, for low cost and fast delivery. Or you can order custom machined screws for critical or extreme precision applications. Saginaw has successfully built screws from 1½ inches to 39½ feet long—⅛ inches to 10 inches diameter.

MANY TYPICAL APPLICATIONS

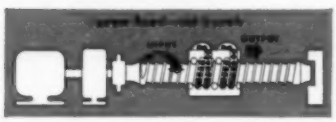
Saginaw b/b Screws have been applied to automatic garage doors, automobile seat adjusters and window lifts, barber chairs, hospital beds, bumper jacks and circuit breakers. Or they can be used for heavy industry equipment like die table positioners, drill presses, lift trucks and welders.

FREE ENGINEERING HELP FOR YOUR SPECIAL APPLICATION

Let Saginaw's experienced engineers help solve your special application problems. Just write or phone us—no obligation.

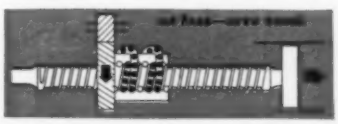
Automatic Garage Door lifts and lowers easily and smoothly when actuated by Saginaw b/b Rolled Thread Screw.

HOW THE WORLD'S MOST EFFICIENT ROTO-LINEAR DEVICE WORKS



When rotary motion is applied to the screw, the b/b nut is driven along the axis of the screw, changing rotary motion to linear motion with over 90% efficiency.

When rotary motion is applied to the b/b nut, the screw is driven along its longitudinal axis, changing rotary motion to linear motion with over 90% efficiency.



SEND TODAY FOR FREE 1958 ENGINEERING DATA BOOK

or see our section in Sweet's Product Design File

Saginaw Steering Gear Division
General Motors Corporation
b/b Screw and Spline Operation
Dept. 5AUT, Saginaw, Michigan

Please send new engineering data book on Saginaw b/b Screws and Splines to:

NAME _____

COMPANY _____ TITLE _____

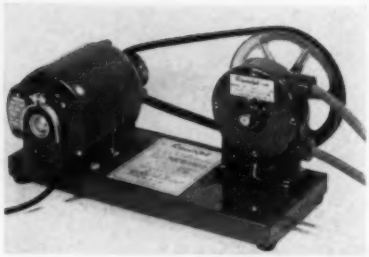
ADDRESS _____

CITY _____ ZONE _____ STATE _____

Saginaw
ROLLED THREAD ball bearing Screw

SAGINAW STEERING GEAR DIV., GENERAL MOTORS CORP., SAGINAW, MICH.

Circle 710 on Page 17

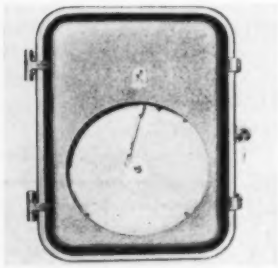


Abrasive Slurry Pump

Item 441

Pump is designed to handle all types of abrasive solutions and slurries. Continuous flexible tube passes through the pump body from intake to outlet and is exposed to the action of a rotatable lobe member. When suitable tubing material is used, the pump will operate free of corrosion, contamination, and wear from abrasive particles. It is adaptable to pump cutting and cooling fluids where abrasive particles of a size not easily held by a strainer are present. **Randolph Co.,** 1018 Rosine St., Houston, Tex.

Circle 441 on Page 17

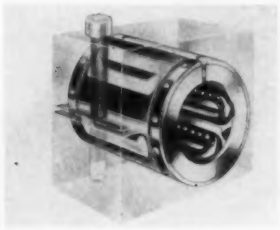


Recording Thermometer

Item 442

Unit automatically records temperature of oil in custody transfer operations. Model TRW uses the mercury expansion principle and will record on a circular chart the minute-by-minute temperature changes in the crude oil at the time of delivery to the pipe line. A mercury bulb, suspended vertically in the tank, samples the average temperature of the oil to an accuracy of ½ of one per cent of scale range. The expansion is transmitted through a capillary tube to the instrument body mounted on the outside of the tank. The lever system transmits the expansion from a diaphragm to a recording arm on which a pen is mounted. Thermometers are available in 24-hour, 48-hour, or 7-day chart movements, electric or spring driven. **Partlow Corp.,** 503 Campion Rd., New Hartford, N.Y.

Circle 442 on Page 17



Linear Ball Bearing

Item 443

Adjustable diameter ball bearing for linear motion is suitable for use in machine tools, special machinery, small precision mechanisms, and other mechanisms where free linear motion is needed and shake or play is detrimental. The bearings are split longitudinally, and are designed to provide line-to-line or slight preload fits when mounted in an adjustable diameter housing. The bearings enable the tolerance on both the shaft diameter and bearing bore to be adjusted out, and compensate for wear that can develop in severe applications. Device is available in standard sizes for shaft diameters from one inch to four inches. **Thomson Industries Inc.,** Manhasset, N. Y.

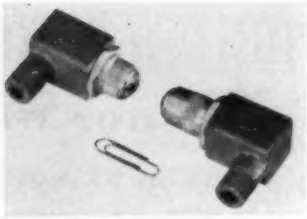
Circle 443 on Page 17

Zinc and Lead Detector

Item 444

Applicable for accurate counting of zinc and lead parts, proximity coil has a nonmetallic housing consisting of a nylon liner, bakelite bobbin, and bakelite shell. Leads enter the housing through a Bendix connector. Zinc and lead parts passing through the coil actuate the control relay by producing a phase shift. Sensitivity is controlled by adjusting a screw which distorts the field of one primary and one secondary winding to unbalance the system. The nonmagnetic material passing through the coil balances the system and actuates the relay. **Automatic Timing & Controls Inc.,** King of Prussia, Pa.

Circle 444 on Page 17



Photoelectric Scanner

Item 445

Miniature device provides whole-light-beam interruption by 1/32-inch diameter objects. Small objects moving at a fast rate can operate the photoelectric scanner. Photocell will respond to reflected or direct light. Light source has a rated life of over 5000 hours, and operates on 6.3v. Beam has an adjustable focus for sharp definition of light source.

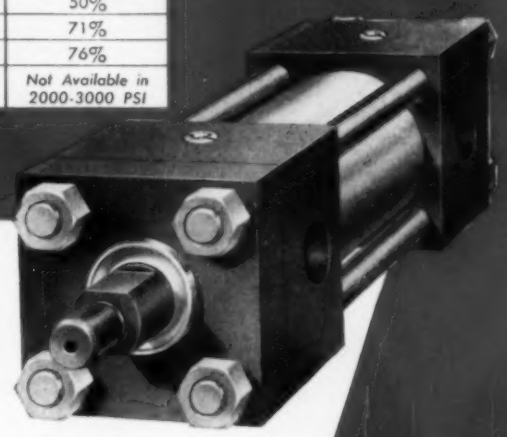
Two types of miniature photocells are available for the pickup head. The cadmium-selenide photoconductive cell can operate a sensitive relay directly for moderate-speed operation. With an electronic relay it will work up to distances of 6 feet. The lead-sulphide cell is used in conjunction with an electronic relay for high-speed operation. Three types of response are possible by choice of electronic relays: Operation of load relay for as long as the beam is interrupted; operation by beam-interruption of less than 1 millisecond by fast-moving objects with load relay hold-in up to one second; and operation after a time adjustable up to one second, with no response to interruptions of less duration than preset time. The light source and photocell head are available separately for use with

Save 27% or more in cost...

NEW Miller "JOB RATED" HYDRAULIC CYLINDER LINE

JOB RATED, MODEL "LH"

BORE	CONTINUOUS SERVICE RATING	INTERMITTENT SERVICE RATING	YOU SAVE THIS % IN PRICE OVER STANDARD 2000-3000 PSI CYLINDERS
1½"	1500 PSI	2500 PSI	27%
2	1500	2500	27%
2½	1000	1500	28%
3¼	1500	2500	32%
4	1000	1500	35%
5	800	1200	37%
6	800	1200	43%
8	500	800	50%
10	500	800	71%
12	500	800	76%
14	500	800	*Not Available in 2000-3000 PSI*



with IDENTICAL seals, design, and safety factors as the famous Miller "Power-Packed" Model "H" Line for 3000-5000 psi service.

ALL TEFLON* SEALED AGAINST EXTERNAL OIL LEAKAGE

SHEF SEAL
At Tubing Ends

Has zero axial clearance, metal backup, no "blind assembly." Teflon sealing strip of one cross-section dimension for all cylinder sizes—supplied on convenient spools.

Shear-proof
Heat-proof
Extrusion-proof
Fluid-proof

Piston Rod Flange Seal

Self-regulating, wear-compensating piston rod flange seal is pressure-energized, guaranteed leak-proof and never requires adjustment.

Teflon rod wiper keeps dirt out. Teflon hydraulic wiper keeps lubricant in.

Teflon sealing strip for bushing is one cross-section dimension for all cylinder sizes — supplied on convenient spools.

LOCK-SEAL
Cushion Adjusting Screw

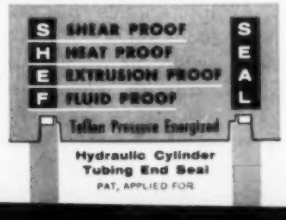
Non-protruding screw automatically sealed and locked by Teflon ring. Interchangeable with ball check assembly for easy access.

CASE-HARDENED CHROME-PLATED PISTON RODS

Heat treated, stress relieved, high tensile steel piston rods, case-hardened, then hard chrome-plated.

NOW! . . . You can save MORE with quality Miller "Job-Rated" Cylinders than with cut-price, lesser quality hydraulic cylinders. And the "Job-Rated" Cylinders are also available under the same immediate shipment program (2 hours if necessary—3 days normal) as the Power-Packed Line.

*Du Pont trademark for its tetrafluoroethylene resin



OTHER MILLER QUALITY FEATURES

- Rust-Resistant Surfaces
- Interchangeable, Space-Saving Square, 4-Tie-Rod Design
- Air Bleed In Cylinder Head
- Precision Honed Barrels

Circle 711 on Page 17

MILLER FLUID POWER
DIVISION OF [illegible] CORPORATION

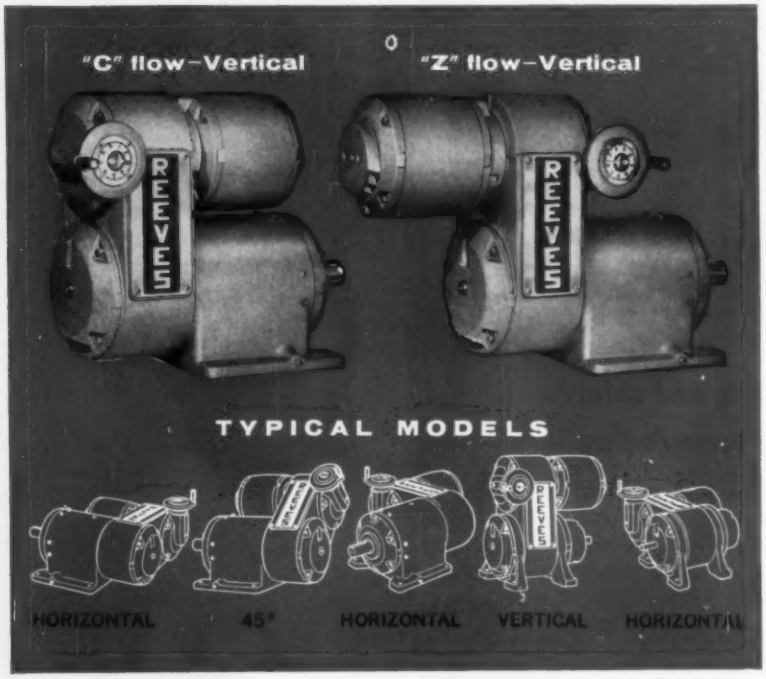
2015 N. Hawthorne Ave. Melrose Park, Illinois

AIR AND HYDRAULIC CYLINDERS • ACCUMULATORS
COUNTERBALANCE CYLINDERS • BOOSTERS

NEW **REEVES**®

*Sizes 200-300 Vari-Speed MOTODRIVES**

**200-300 Size, 1 through 5 hp.; full line, ¼ through 40 hp.*



The flexible design of these compact new REEVES variable speed power packages permits hundreds of combinations . . . space-saving, space-fitting *standard* assemblies to meet most installation requirements. All models are available in both "C" flow and "Z" flow styles.

New increased capacity is built in the reducers—single, double or triple stages...new disc assemblies permit wider output speed ranges . . . discs are pre-aligned . . . pre-loaded spring maintains correct belt tension for longer belt wear . . . *exclusive* "close-grooving" lubrication assures free sliding discs . . . new Metermatic system automatically lubricates the motor and variable shaft bearings.

Complete information on all phases of the versatile 200-300 sizes Vari-Speed Motodrives is given in new Catalog. Write for your free copy today—Dept. AN32-M571.

REEVES PULLEY COMPANY

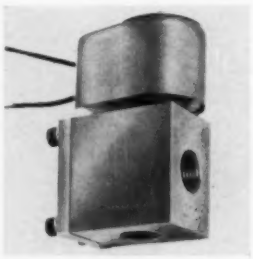
Division of **RELIANCE** ELECTRIC AND ENGINEERING CO.

Columbus, Indiana

Circle 712 on Page 17

existing equipment. **Farmer Electric Products Co. Inc.**, 2300 Washington St., Newton Lower Falls, Mass.

Circle 445 on Page 17

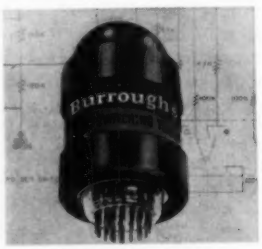


High Pressure Valve

Item 446

Suitable for hydraulic applications such as hydraulic lifts and elevators, valve is designed for tight shutoff on pressures to 1500 psi. It can be mounted in any position without affecting operation. Valve is of the internal pilot operated piston type with an angle body and is available only for normally closed operation. A minimum operating pressure of 25 psi is required to open the valve and to maintain full flow. Valve is available for ½ or ¾-inch pipe connections. **Automatic Switch Co.**, Florham Park, N. J.

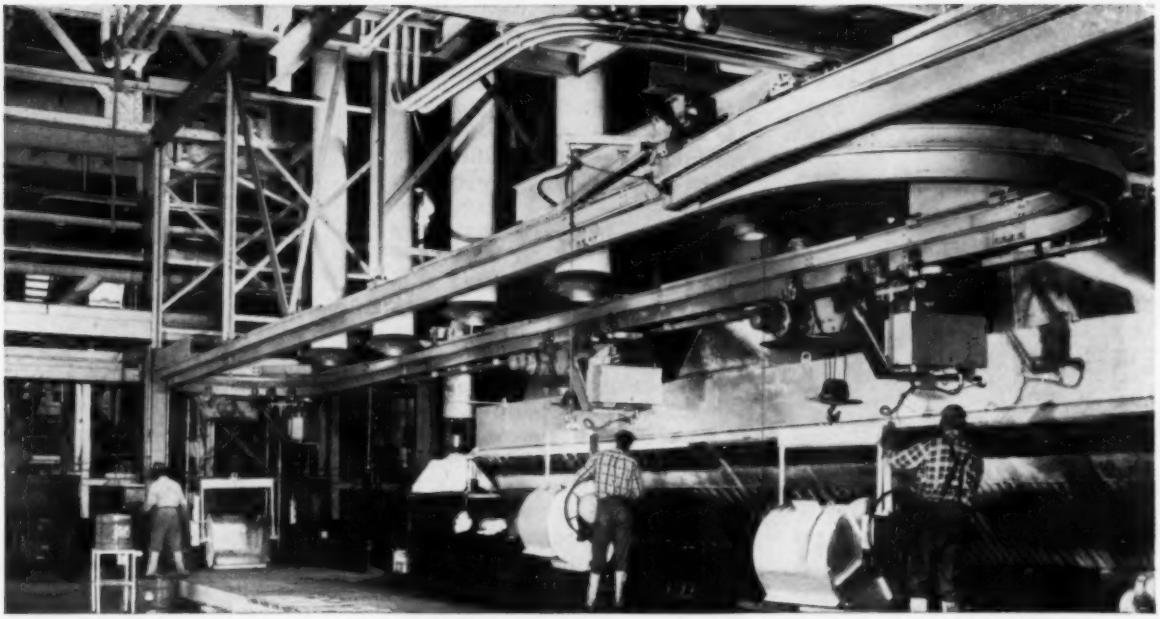
Circle 446 on Page 17



Beam Switching Tube

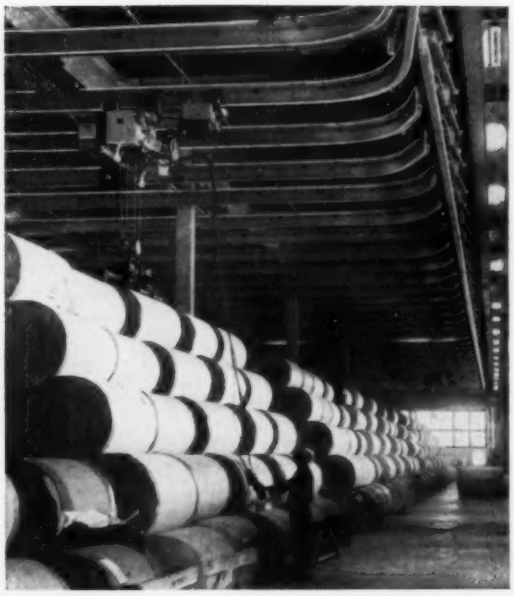
Item 447

Unit is capable of performing the functions of 20 or more tubes or transistors. It is suitable for use in instruments, industrial control computers, telemetering, radar, frequency dividing, and timing. Device has a life span of 50,000 hours, a high input impedance, and ten individual constant-current outputs. Characteristics of the tube line include shock 375 g; temperature range of − 60 to + 150 C; vibration 20 g; and a



Here's a way to make your lost ceiling space pay off

AMERICAN MONORAIL



Floor space is unobstructed, free of traffic with American MonoRail overhead handling.

increases plant capacity... cuts handling costs... reduces worker fatigue... minimizes damage and loss.

You can get more profit out of your plant. American MonoRail Engineers can show you how to convert lost ceiling space – eliminate obstructive storage around machines – and gain additional operating area. Find out how you can process work in motion, cut down idle time, and assure safe handling of product. Work can be done at comfortable heights – worker fatigue lessened – heavy loads eliminated – and damage to product reduced.

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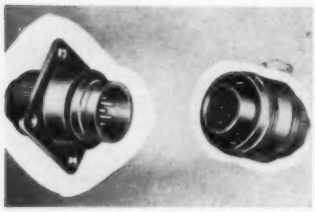
speed up to 20 mc. Model 6700 operates between 75 to 300v with a switching rate above 2 mc and Model 6701 from 12 to 25v with a switching rate above 1 mc. **Electronic Tube Div., Burroughs Corp.,** Plainfield, N. J.

Circle 447 on Page 17



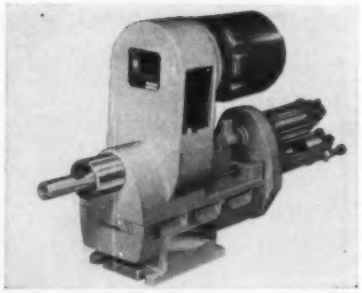
Connectors

Item 448

Line of connectors is available in three sizes with 3 shell configurations: Model QO2, a square-flanged receptacle; Model QH25, a hermetically sealed round-flange receptacle; and Model QO6, a straight plug. Resilient grommets are incorporated on the back of the QO2 receptacle and QO6 plug. Units have internal restrictions which will seal an 0.050 OD to 0.105 OD range of wire sizes. Receptacles have a rubber sealing ring located forward of the insert face. When the plug mates with the receptacle, the ring seats against and around the barrel of the plug, giving a completely sealed connector.

Engagement is accomplished and locked by means of a beryllium copper latch within the plug coupler assembly. The latch is contained with a spring-loaded sleeve, which, when pulled back, releases the latch for engagement. With the latch released the plug is mated to the receptacle, allowing the formed ends of the latch to slip into a groove around the receptacle. When the coupler is released the spring-loaded sleeve is thrust forward over the latch. When engaged, the sleeve locks the ends of the latch into the receptacle groove, effecting a mated connector which resists vibration without the use of safety wiring. **Cannon Electric,** 3208 Humboldt St., Los Angeles 31, Calif.

Circle 448 on Page 17

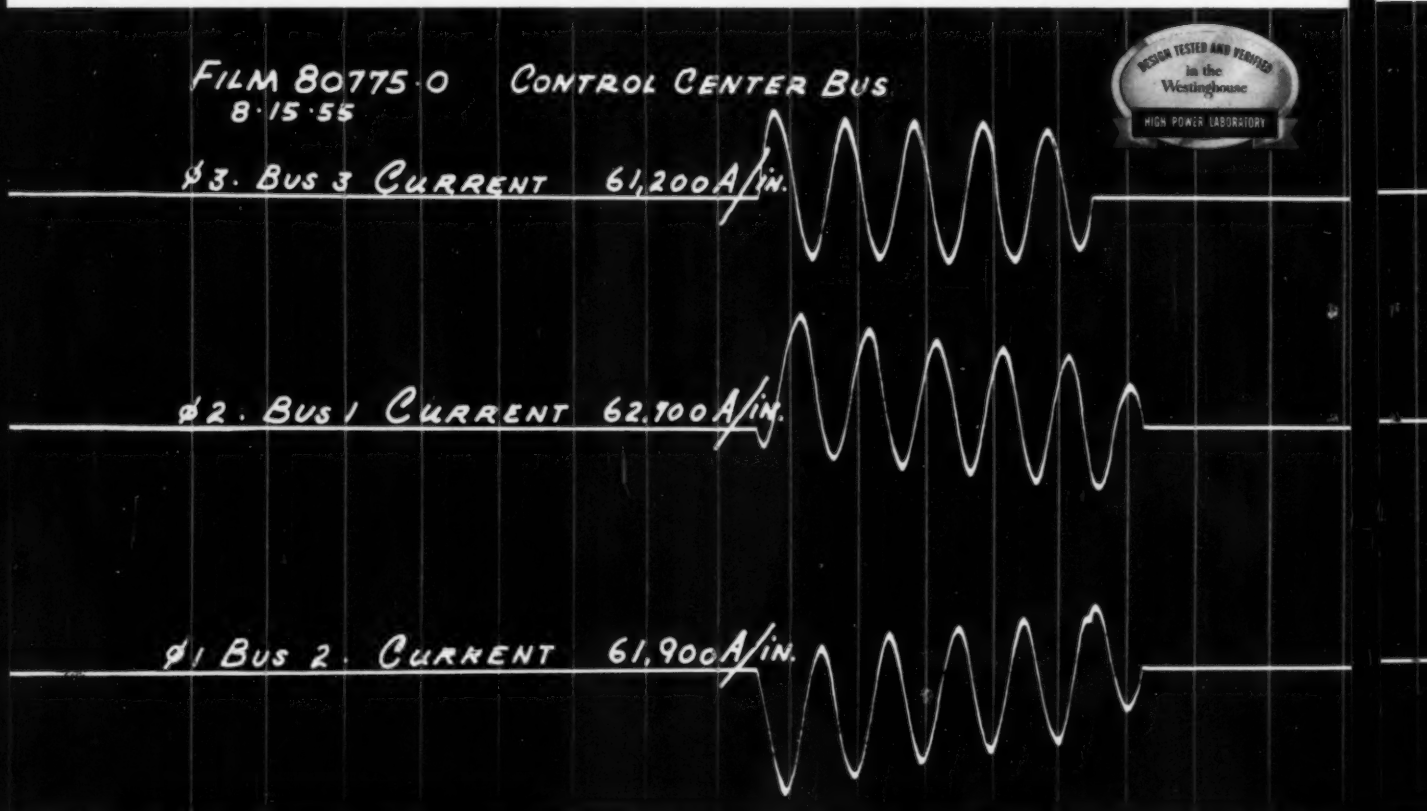


Drilling Unit

Item 449

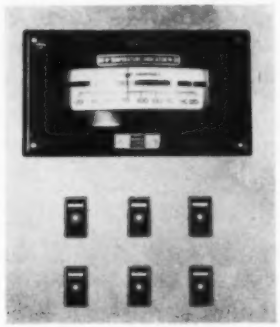
Adaptable in the metalworking field, automatic drilling unit can drill, ream, counterbore, spotface, or tap any machinable material. The complete machining cycle is started upon reception of an electrical impulse. The unit has only two bearings and they are prelubricated and sealed.

Off center spindle loading is minimized by mounting the air cylinder, which pushes the spindle forward, directly in line with the drill spindle. This arrangement permits more efficient thrust transmission to the drill and reduces wear on sliding surfaces. Rapid


FILM 80775-0
8-15-55
CONTROL CENTER BUS
DESIGN TESTED AND VERIFIED in the Westinghouse HIGH POWER LABORATORY
ϕ3. BUS 3 CURRENT 61,200A/IN.
ϕ2. BUS 1 CURRENT 62,900A/IN.
ϕ1 BUS 2. CURRENT 61,900A/IN.

approach arresting and feed rate control are provided by a small, compact, sealed hydraulic check unit mounted parallel to and independent of the air cylinder. Unit has spindle speeds from 300 to 3600 rpm, ½ hp to 1 hp. **Gotha Inc.**, Box 430, Harvey, Ill.

Circle 449 on Page 17



Resistance Thermometer

Item 450

Instrument has wire wound resistance elements and can indicate on a meter the temperature in any area of a heating and air conditioning system. The resistance elements are connected to a corresponding switch on a central panel. It enables the operator to periodically check all building temperatures from one point to determine if the air conditioning system is functioning properly. When used in conjunction with electronic temperature controls, the operator can remotely check the temperature at any controlled point and immediately readjust the control setting to compensate for any abnormal variations as they occur.

Thermometer consists of an indicating meter, a bridge and power supply, and as many sensing elements and selector switches as are necessary to check temperatures at all control points required for each application. The power supply insures permanent meter calibration by providing a constant power output to the bridge, regardless of line voltage fluctuations. Maximum accuracy is achieved through the use of three conductors to connect the electronic bridge to its sensing elements regardless of the distance between their locations. The temperature indicator is available with either of two standard scales: −20 F to +230 F or +20 F to +120 F. Four types of sensing elements available are room, duct, immersion and outdoor. **Barber-Colman Co.**, 1300 Rock St., Rockford, Ill.

Circle 450 on Page 17

Digital Weighing System

Item 451

Suitable for batch weighing applications, digital weighing system has an accuracy of 0.1 per cent. System includes a digital indicator and a load cell containing a strain gage pickup. The indicator features a continuous-balance electronic potentiometer and a servo-

Westinghouse CONTROL CENTER design tested at 25,000 amperes to insure safety for personnel and equipment

At the Westinghouse High Power Laboratory, the new Westinghouse Control Center design has been thoroughly tested under maximum fault conditions with no damage to equipment . . . conclusively proving it industry's safest control center.

With complete interchangeability between 9½-and 14-inch modular units, simplified installation and increased safety, Westinghouse Control Centers make possible the most compact, economical, centralized control systems.

For complete information on the Westinghouse Control Center, call your Westinghouse sales engineer, or write Westinghouse Electric Corporation, P.O. Box 868, 3 Gateway Center, Pittsburgh 30, Pa.

J-22102

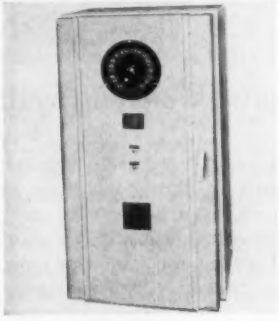
POWER-UP starts with CONTROL

YOU CAN BE SURE...IF IT'S Westinghouse

motor driving precision number wheels.

Readability of the system is one part in ten thousand using four number wheels. Output readings can be calibrated in any quantities such as pounds or ounces, or it can be calibrated in pieces so the system can be used for weigh-counting. Unit is also available with coded digital output for connection to computers or central recording stations. **Performance Measurements Co.,** 15301 W. McNichols Rd., Detroit 35, Mich.

Circle 451 on Page 17

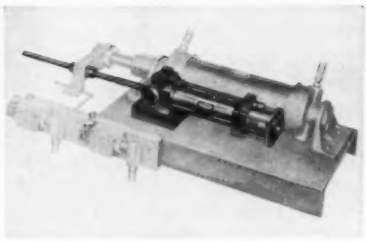


Speed Controller

Item 452

Close speed regulation with a conventional off-the-shelf-type ac motor is obtained over a wide speed range with this variable speed controller. Using a dc tachometer generator for feedback of motor speed, regulation of ±1 per cent over a speed range of 1050 to 1530 rpm is obtained via power magnetic amplifiers in series with rotor-circuit resistors. Model 2027 can be directly coupled to an ac generator whose output frequency controls the speed of a squirrel cage motor. Speed is controlled by regulating the generator drive and the generator frequency output. Frequency accuracy is maintained at ±1 per cent from no load to full load over a generator frequency range of 44 to 61 cycles and with line voltage variations of ±10 per cent. Maximum frequency drift after start up is ±¼ per cent. Operating frequency of the unit can be preset or adjusted while running. Frequency can be read from an indicating dial on the hinged controller door. **Warren Mfg. Co.,** Littleton, Mass.

Circle 452 on Page 17

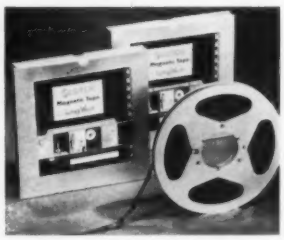


Checking Cylinder

Item 453

Line of hydraulic cylinders is designed for use with air cylinders to smooth out stroke variation under irregular loads. When used with the air cylinder, device provides uniform controlled speed for feed on drilling, milling, cutoff, grinding, and other machine operations. A dial sets the speed control. Maximum checking capacity is 2000 lb on the out stroke, with free return. Seven models covering 2 to 18-inch checking stroke lengths are available. **Modernair Corp.,** 400 Preda St., San Leandro, Calif.

Circle 453 on Page 17



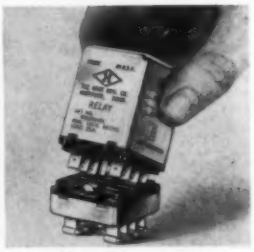
Magnetic Tape

Item 454

Tape is applicable to telemetering systems, computers, tape control systems for machine tools, and geophysical recording. Constructed of a durable binder, tape has a smooth oxide surface which decreases head wear. A durable polyester backing is used for maximum dimensional stability over a wide range of temperatures and humidity.

The tape contains no more than one drop-out per 2500 foot roll. This is measured by recording 200 nonreturn pulses per inch on a 0.035-inch track. A reduction to less than 50 per cent normal signal amplitude constitutes a signal error. Zero errors are measured by saturating the tape unidirectionally. Each spurious signal greater than 10 per cent of normal signal amplitude constitutes a zero error. Errors per roll are based on recording 7 tracks on rolls ½-inch by 2500 feet. Tape is available in ¼, ½, ⅝, ¾, and 1-inch width. **Minnesota Mining and Mfg. Co.,** 900 Bush St., St. Paul 6, Minn.

Circle 454 on Page 17



Plug-In Relay

Item 455

Adaptable for use in automatic equipment, motor starting or heater circuits, clock controlled systems, machine tool control panels, air conditioners, and similar applications, relays are available with standard ratings up to 25 amp resistive at 115-230v, ac; 1 hp, 125v, 2 hp, 250v ac. Independent socket makes it possible to wire a complete chassis or assembly before plugging in the spade-terminal relays. Socket leads can be connected to a panel or terminal board for easy rearrangement of sequencing. **Hart Mfg. Co.,** 110 Bartholomew Ave., Hartford, Conn.

Circle 455 on Page 17

Valve Actuator

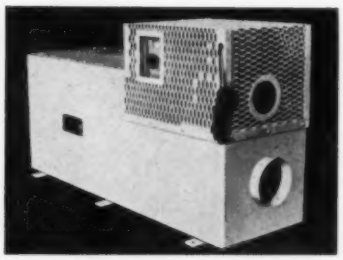
Item 456

Feature of unit is the split-coupling which joins the pneumat-

ic actuator spring stem to the valve plug stem. By loosening three nuts, the actuator can be lifted over the plug stem. The slotted holding clips and the coupling arrangement allow the actuator to be completely removed without disturbing the packing box bolting.

Coupling has LH and RH threads, and in addition to being a twist-proof clamp for joining the stems, it also acts as a turnbuckle for the adjustment of plug seating tension. No valve disassembly is required when positioner is mounted in the field. Each valve is equipped with a universal bracket for the mounting of any positioner. Actuator is available in three standard sizes, each size covering twelve different constructions. **Hammel-Dahl Co.**, Warwick Industrial Park, Providence 5, R. I.

Circle 456 on Page 17



Humidity Controller

Item 457

Device can be used with humidifiers, dehumidifiers, and air conditioning equipment. Controller includes a sensing element, control system, and modulating device. It can maintain a relative humidity level within $\pm\frac{1}{4}$ per cent in an air or gas stream. A calibrated knob sets or adjusts the control point. Unit is available in sizes ranging up from 20 cfm. **Universal Dynamics Corp.**, Dept. A, Box 9797, Arlington, Va.

Circle 457 on Page 17

Variable Speed Drive

Item 458

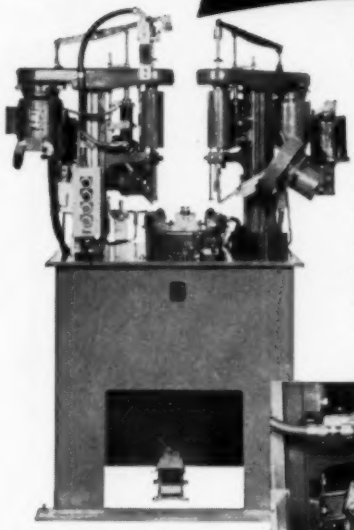
Electrical control system provides remote setting of speed with high accuracy or adapts the transmissions for use in automatic speed control systems such as tension and velocity control, register

control, load control of grinders and pulverizers, blending and proportioning control, etc. The remote control unit includes a precision speed indicating meter calibrated from zero to 100 with linear readings over the entire range. A ratio adjusting knob behind the front panel of the indicator can be set to provide linear full scale readings for as little as 1/10 the normal speed range. Device permits remote or automatic control without loss of accuracy. Unit is designed for panel or base mounting. **Graham Transmissions Inc.**, Menomonee Falls, Wis.

Circle 458 on Page 17

JOB NUMBER SP-9514

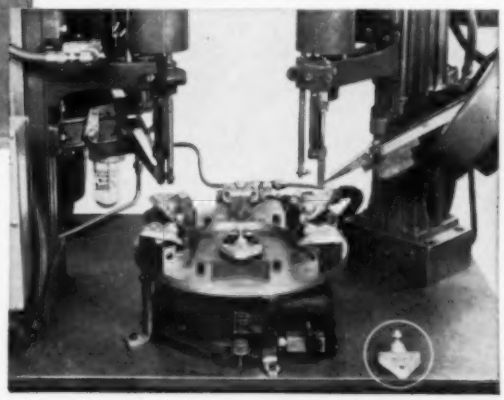
DPS "built-in" mechanical skill



● Pictured is a specially designed machine used for assembling

REAR VIEW MIRROR SWIVEL BRACKETS

The machine consists of two driving heads with automatic feeding devices with an indexing type fixture . . . The operator simply preloads the component parts of the assembly into the dial, and as the dial indexes two screws are driven into the swivel pressure plate at proper tension for adjusting the mirror.



● No mirrors? O.K. No matter what you make, if there's parts to be assembled you'll find the mechanical answer in D.P.S.

POWER SCREWDRIVERS
SELECTIVE PARTS FEEDERS
SPECIAL ASSEMBLING MACHINES

specially adapted to serve your individual feeding and assembling needs at a higher production rate, lower cost, and with greater earnings.

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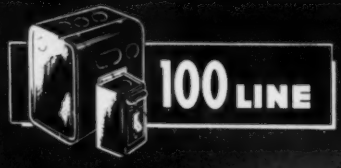
Circle 715 on Page 17

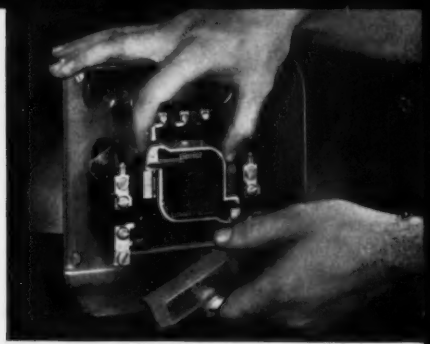
Easy Overload Adjustment, 10-Second Coil Removal, 9 Modification



100 LINE

OVERLOAD ADJUSTMENT. The small knob on top of each overload relay allows you to make finger-tip adjustments of the overload trip setting between plus or minus 15% of nominal heater rating—ends nuisance tripping.

FAST



FAST COIL CHANGE. Remove the spring clip and "I" magnet, lift off the coil terminals, and slip out the coil. General Electric strong box coils are available in ratings from 110 to 600 volts and 25 to 60 cycles.

Kits Make NEW General Electric Size 0 and 1 MAGNETIC STARTERS

EASY TO APPLY

General Electric's new, radically different magnetic starter is quick and easy to apply. Overload adjustments and coil change do not even require a screwdriver. In addition, each modification kit can be added in the standard general-purpose enclosure.

Like more information? Contact your nearby G-E Apparatus Distributor, or write to Section 733-42, General Electric Company, Schenectady, N. Y. and ask for bulletin GEA-6611.

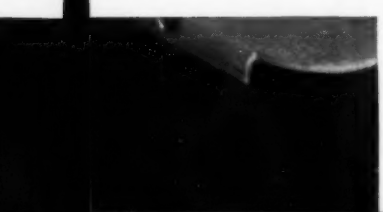
Also ask about the new General Electric manual starter for single-phase fractional-horsepower motors. It has the exclusive new plug-in heater that can be installed in a few seconds. The new starter fits any standard wall box. Ask for bulletin GEA-6358. General Purpose Control Dept., Bloomington, Illinois.

MODIFICATIONS FOR ANY APPLICATION

AUXILIARY CONTACTS. You can add, inside the enclosure, up to three contact units for additional circuits. These auxiliary contacts can be changed from normally open to normally closed without additional parts.

INDICATING LIGHT IN COVER. This exclusive G-E feature permits you to add an indicating light in the cover of non-reversing and combination general-purpose enclosures. The light can be used with voltages up to 550 volts.

MODIFICATION KITS. In addition to coil, auxiliary contact, and indicating light kits, you can get push button, selector switch, auxiliary pole, third overload relay, fuse clip, and adaptor plate kits for the new starter.



GENERAL ELECTRIC

Circle 716 on Page 17

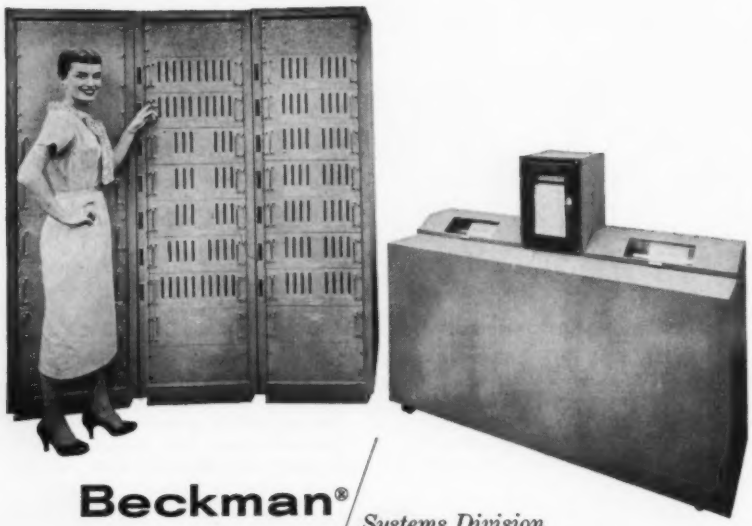
Magnetic-Core Coil Classifier Inspects Tin Plate Continuously, Automatically

Beckman coil classifiers are measuring and recording characteristics and defects of tin plate around-the-clock, in continuous on-line operation. Linear travel, pinhole footage, over- and under-gage tolerances, coatings, quenching strain, slivers, abrasions, damaged edges are all detected and recorded while coils are rolling and shears flying.

Data from detectors is supplemented by manual entries showing date, purchase order, coil, line, and turn numbers. All information is then delayed for correct relationship to shear position. Upon shear activation, the appropriate totalized data is recorded on preprinted formats, with separate records for quality control and customer information. This in-process correlation of upstream detection with shear control and data printout permits accurate profiling of product with no lag in production – increases profit margins.

No vacuum tubes are used – all electronic circuitry consists of extremely reliable, toroidal magnetic cores and other passive elements. Without modification, Beckman coil classifiers are compatible with data reduction systems and in-process control.

Coil classifiers are typical of the many reliable system applications of Beckman counters and timers, proved in thousands of field installations. For more information on counting and timing system applications, write for Data File 2D-13-48.



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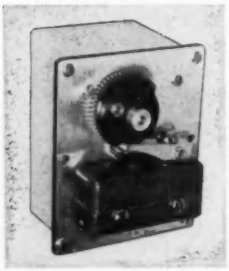
325 N. Muller Ave., Anaheim, Calif.
a division of Beckman Instruments, Inc.

Responsible new positions in engineering, manufacturing, technical marketing. Write for Career File 10.

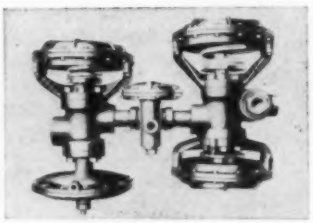


Sequence Timer

Item 459

Suitable for geophysical instrumentation and various airborne applications; sequence timer has a switching capacity of 10 amp at 115v dc, or 15 amp at 115v ac with the driving motor drawing only 8 milliamperes at 6v dc. Model HDC employs a heavy duty cam actuated switch of the magnetic quench type. Speed regulation of the motor is ± 1 per cent over a voltage shift of ± 50 per cent. The actuating cam can be adjusted through a range of zero to 180 degrees, for a wide selection of timing intervals. **Brailsford & Co. Inc.**, 670 Milton Rd., Rye, N. Y.

Circle 459 on Page 17



Control Valve

Item 460

Three-way neutral, two-pressure valve is designed for automatic control of presses and plastic molding machines. Upon actuation, the valve applies low pressure for fast, controlled closing of the press or machine; when triggered by a control timer or limit switch, the high pressure is applied. When processing is completed, high pressure cuts off, the drain valve opens, and the press or machine opens. The valve can be adjusted to provide any throttling speed in any position of the closing and opening strokes. The stem of the valve is in hydraulic balance, and provides smooth, shock-free operation. Pressures increase gradually as

NATIONAL ELECTRIC

solves tough production problem of welding air-suspension brackets for 1958 cars

The new air suspension systems introduced on some 1958 cars, create not only a super-smooth ride for passengers . . . but many production problems for manufacturers. To help lick one of these problems . . . National Electric designed and built two new multi-station arc welders that perform 2 important operations on the structural members of the new systems.

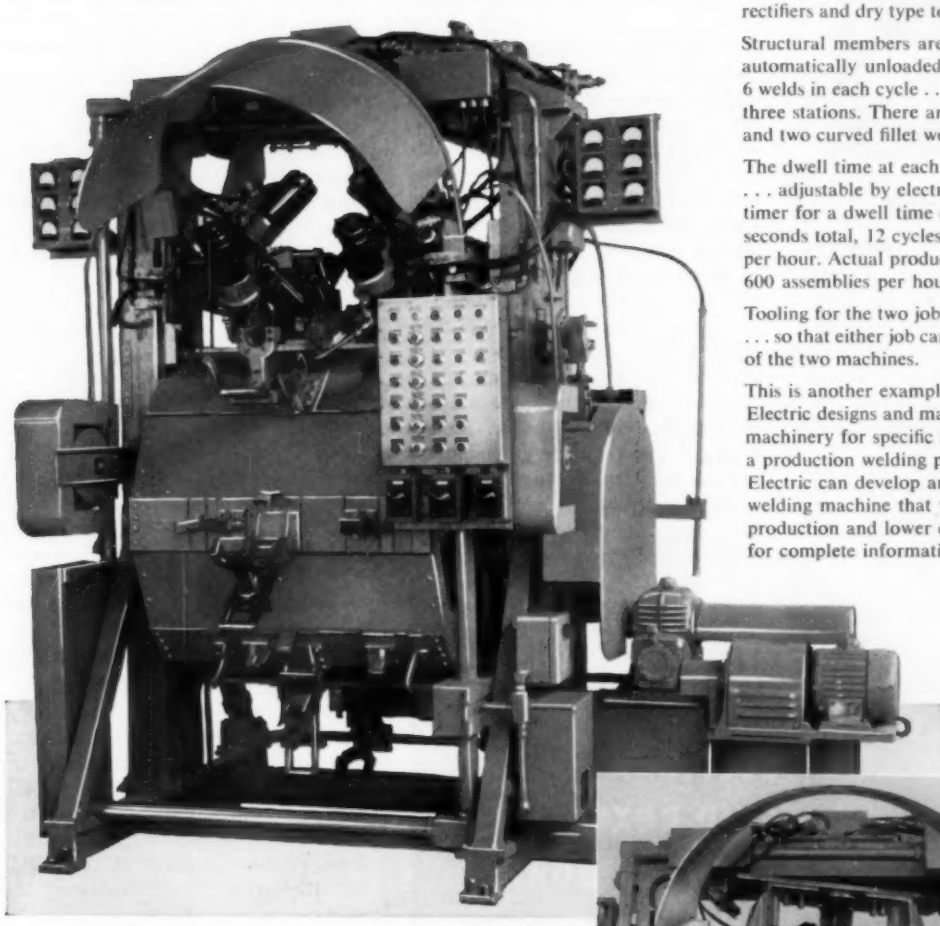
These 6-head, CO_2 arc welders incorporate a drum feed, 8-station Geneva Index, with 800 amp. rectifiers and dry type torches.

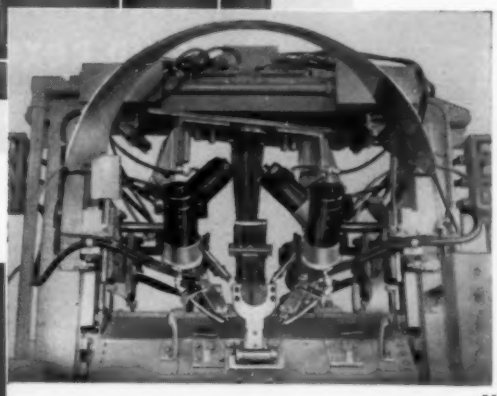
Structural members are manually clamped and automatically unloaded. The machines complete 6 welds in each cycle . . . two at each of three stations. There are four spot welds . . . and two curved fillet welds each two inches long.

The dwell time at each index is 1⅞ seconds . . . adjustable by electric clutch brake and timer for a dwell time of 3⅛ seconds, five seconds total, 12 cycles per minute or 720 cycles per hour. Actual production is approximately 600 assemblies per hour.

Tooling for the two jobs is interchangeable . . . so that either job can be run on either of the two machines.

This is another example of how National Electric designs and manufactures welding machinery for specific applications. If you have a production welding problem . . . National Electric can develop an automatic welding machine that will assure higher production and lower cost per weld. Write for complete information.





55

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25 YEARS EXPERIENCE DESIGNING AND BUILDING: SPECIAL & STANDARD • AIR • HYDRAULIC • MOTOR DRIVEN • SPOT • PROJECTION • SEAM • BUTT • FLASH • RESISTANCE WELDERS • PRODUCTION FIXTURES FOR ALL TYPES OF AUTOMATIC ARC WELDING.

the stem uncovers the port holes in the seat sleeve. **Sinclair-Collins Valve Co.,** 454 Morgan Ave., Akron, Ohio.

Circle 460 on Page 17

Tank Gaging System

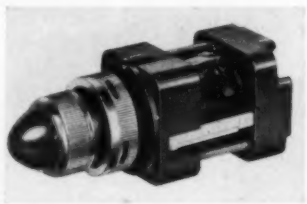
Item 461

Transistorized electronic system measures the level of liquid within 1/16 inch in as many as 100 remotely located storage tanks. System uses three types of compact units—receiver console, field selector unit, and liquid level gage with power float.

The console contains the instrumentation which initiates interrogation, decodes, and checks the telemetered data, displays the correct data points, and supplies intelligence for printer, teletype, computer, or other equipment as desired. Tank numerals and depths from zero to 64 feet to the nearest 1/16-inch are displayed in columns on the inclined panel. The entire housing hinges backward for ready access to all components without taking unit out of operation.

A digital code in binary decimal form is used in the system. Each decimal group and its complement are transmitted simultaneously by separate channels. If any group fails to check itself, the interrogation is halted, and the error signal actuated. The power float uses a surface tension principle to measure the liquid level. As the float moves upward, liquid is trapped in its recessed bottom, making the tension somewhat greater than the free weight of the float and cocking the surface break detector in the gage head. At the instant the surface tension is broken and the cable tension becomes equal to the free weight of float, the break detector is triggered and registers a reading through the code generator. Three separate automatic checks are made for accuracy before data are displayed on the Data-Gage: The power float must trigger the surface break detector at the exact time the surface tension breaks if the code generator is to be activated; the code generator must transmit the exact number of pulses or the error signal will be lit; and the telemetered decimal group, its complement, and the entire data point are checked for completeness and any false part actuates the error signal. **Industrial Instrumentation Div., Texas Instruments Inc.,** 3609 Buffalo Speedway, Houston 6, Tex.

Circle 461 on Page 17

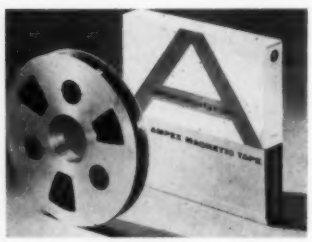


Push-To-Test Light

Item 462

Pilot light is constructed so bulb can be tested by pushing on the color cap. There is a positive contact feel when the unit is actually in the test position. The oil-tightness of the unit is maintained in the normal and test positions. All internal connections are pressure connections of silver-plated beryllium copper. **Square D Co.,** 4041 N. Richards St., Milwaukee 12, Wis.

Circle 462 on Page 17



Magnetic Tape

Item 463

Tape, which is used for telemetering, process control, and computer input and output, is in-

spected for output level and signal loss due to dropouts. Each roll is recorded and played back in the checking process, then automatically de-gaussed before packaging. **Ampex Corp.**, 934 Charter St., Redwood City, Calif.

Circle 463 on Page 17

Magnetic Disc Brake

Item 464

Electromagnetic disc brake has a single solenoid construction, is easily assembled and disassembled for maintenance and gives a visual indication of the condition of the friction linings. In operation, the spring-set solenoid released brake automatically sets in case of power failure. Units are rated at 10, 15, 25, 35, 50, and 75 lb-ft maximum torque. **Stearns Electric Corp.**, 120 N. Broadway, Milwaukee 2, Wis.

Circle 464 on Page 17

Plug and Receptacle

Item 465

Line of electrical connectors can be used on limit switches, pushbuttons, small motors, solenoids, and temperature controls. Receptacle is made up of two parts—a threaded aluminum mounting shell and a molded, insulated insert with pigtail wiring leads. Plug is permanently molded to cable as a one-piece Neoprene insulated unit.

Receptacle threaded to fit standard pipe threads can be screwed directly into tapped holes in panels or wiring boxes. Hex nut supplied with each unit also permits mounting receptacles in knock-out holes of wiring ducts, outlet boxes and other sheet metal enclosures. Plug is equipped with threaded aluminum couplings that prevent accidental disconnects and insure moisture and dusttight connections when fully screwed home over receptacle shells. Connectors are available with 2, 3, or 4 contacts for 8 through 20 amp applications at a 600v maximum rating. **Electrical Products Div., Joy Mfg. Co.**, Dept. 0-15, 1201 Macklind Ave., St. Louis 10, Mo.

Circle 465 on Page 17

Load Switch

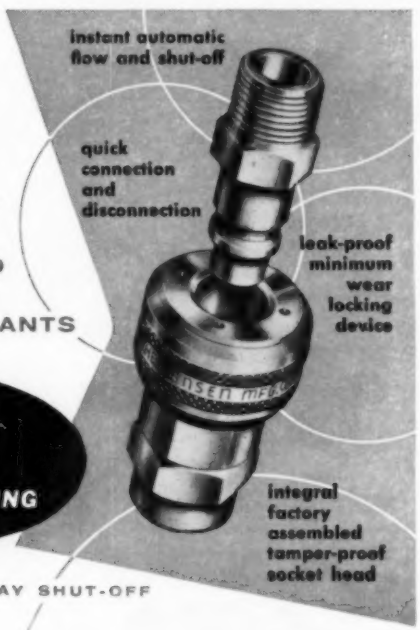
Item 466

Switch is capable of controlling overload conditions of both fractional and multiple horsepower electric motors. It is applicable

Thoroughly Proved...

BY YEARS OF HARD EVERYDAY USE IN THOUSANDS OF PLANTS

HANSEN
QUICK-CONNECTIVE
PUSH-TITE COUPLING


instant automatic flow and shut-off
quick connection and disconnection
leak-proof minimum wear locking device
integral factory assembled tamper-proof socket head

ONE-WAY SHUT-OFF

Locking pins in Hansen Push-Tite Coupling Socket afford large area contact with Plug, thereby preventing wear and subsequent leakage.

The ability of Hansen Push-Tite Couplings to withstand severe service—with practically no maintenance—has been thoroughly proved by years of hard, everyday use in thousands of plants. The "socket head", which contains the locking device, is factory assembled into a rugged integral unit which cannot be readily injured or have component parts lost by casual tampering.

To connect the Coupling, you merely push the Plug into the Socket with one hand. Flow is instantaneous. To disconnect, push back sleeve on Socket—Coupling disconnects. Flow is shut off instantly and automatically.

QUICK-CONNECTIVE FLUID LINE COUPLINGS for

AIR • OIL • GREASE
HYDRAULIC FLUIDS • WATER
VACUUM • STEAM • OXYGEN
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Here's an always ready reference when you want information on couplings in a hurry. Lists complete range of sizes and types of Hansen Quick-Connective Couplings. Write for your copy.

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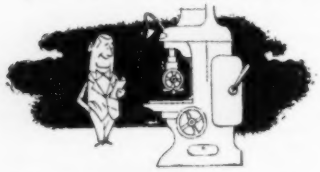
SEE all the very latest advances and improvements in more than thirty major categories of industrial products.



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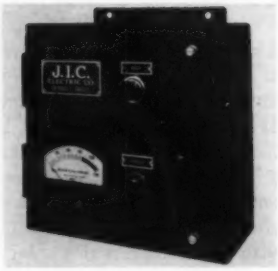
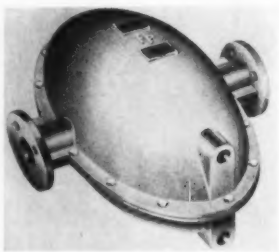
TOOL SHOW CONFERENCE '58 MAY 1 TO 8
OF TOOL ENGINEERS

Circle 721 on Page 17



for detecting misaligned or dulled cutting tools in drilling or milling operations, overloads on conveyors, presses, cranes and mills. Switch requires only two adjustments to set up, uses no vacuum tubes or electronic devices. It operates off 110v, 60 cycle current. Device is available in four standard models: Single overload relay, single overload relay with timer, a double overload relay on which one relay gives warning of a limited overload, and the second stops the machine on excessive overload, or the same unit with timer. **J.I.C. Electric Co.,** 19255 W. Davison, Detroit 23, Mich.

Circle 466 on Page 17



Magnetic Flowmeter

Item 467

Instrument can measure corrosive fluids, slurries, paper pulp, and concentrated acids. In operation, a signal voltage enters a closed null-balance servo loop through the flux rebalancing network. A feedback signal from the reference slidewire driven by the servomotor actuating the indicator is applied to the same network. The two signals are compared, and if there is a change of input, the error signal is fed to a stable high gain servoamplifier which magnifies the signal sufficiently to reposition the servomotor-driven indicator, providing positive indication of volumetric flow.

A manual range adjustment permits the setting of any required maximum flow value. A gain adjustment is also included in the amplifier for stabilization of the flow indication. Meter can be installed directly into the pipeline in any position and flow can be measured in either direction without additional meter adjustment or relocation. **Fischer & Porter Co.,** 292 Jacksonville Rd., Hatboro, Pa.

Circle 467 on Page 17

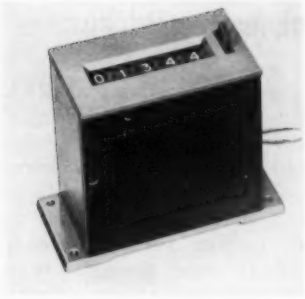
Grinding Gage

Item 468

Device is capable of controlling complete grinding cycle. The gage head includes a primary bellcrank with a single crowned carbide point, a secondary bellcrank with two crowned carbide points, and the gage block itself with three crowned carbide points, two on one side, and one on the other. As the work diameter decreases, the gage plunger rod actuates the primary bellcrank, opening the gap between the primary and secondary cranks. Size is obtained when the gap is great enough for the gage block to pass through. The gage block makes a contact which signals the machine controls.

Unit is available with single, double, or triple signals to the machine controls. The single switch controls size only. The double switch controls the final finish feed, then retracts the wheelslide at size. The triple switch is used for additional slower feed where even finer finishes are necessary. Variations of these models are furnished for spline grinding and other special applications such as face and surface grinding. **Foster Engineering Co.,** 4200 N. Woodward Ave., Royal Oak, Mich.

Circle 468 on Page 17

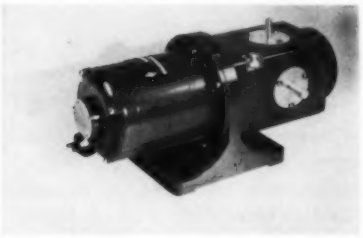


Electric Counter

Item 469

Device is applicable on electronic computers, card and check sorters, coin counters, electronic scalers, mailing equipment, photoelectric and remote counting arrangements, test equipment, and light production machinery. Model YE is capable of up to 1500 counts per minute, and can be instantly reset to zero either electrically or with a flick of a pushbutton. Counter is available for panel or base mounting, is rated at 115v, 60 cycle ac; 115v and 28v dc. **Durant Mfg. Co.,** 1997 N. Buffum St., Milwaukee 1, Wis.

Circle 469 on Page 17



Variable Speed Drive

Item 470

Device is applicable on coil winding machines, process controls, mechanical servo units, and automatically operated equipment requiring infinitely variable speed control. The range is infinitely variable from full speed forward to zero, to full speed reverse. Unit is built with integral motor and output shaft which extends out both sides, providing two outputs. Variable speed control shaft on top of unit requires input of 30 degrees to cover full range. Control force required is two or three inch-ounces torque. Frequency response is less than 0.05 second from full speed forward to full speed back-

STOP!
Material Spoilage
Machine Damage
Operator Injuries
Breakdowns and
Plant Tie-ups
with
Quick-As-Wink
AIR AND HYDRAULIC
Control Valves
¼" "O"-Type Single Solenoid 4-way Valve.
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Play safe. Install Quick-As-Wink valves on all your air and hydraulic controls. Positive and fast acting, all operating parts are in pressure balance, avoiding any tendency to creep or crawl. You'll get month after month and year after year of long, dependable, trouble-free — and safe — service. There's nothing better than a Quick-As-Wink Control Valve. Can you afford to gamble with less? Sizes from ¼" to 4". Hand, foot, cam, pilot, diaphragm or solenoid operated. Thousands of different types, sizes and actions. Get full details.
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AIR AND HYDRAULIC
Control Valves
Mfd. by C. B. HUNT & SON, INC., 2074 East Pershing St., Salem, Ohio
—Engineering and Sales Representatives in the Principal Cities—

Circle 722 on Page 17

Post Decitron
electronic products

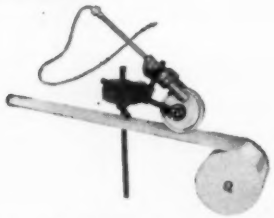
Model SD-1

Versatile, low cost counter — will tabulate up to 50 units per second in continuous operation. Available with totalizer . . . can be placed several hundred feet from switch contacts.

Model P6

Preset electronic counter—up to 5,000 units per second — direct readout totalizer. Will "batch count" any quantity from 1 to 1,000,000. Can be coordinated to secondary circuit for "kicking" devices, etc.

Model LF



Lineal Footage device — can be used with other "Decitron" electronic units to accurately measure and tabulate lengths of wire, rope, sheet stock, paper, cloth, etc. May be used with digital readout printer or visual totalizer on counter.

POST ELECTRONICS
Division of Post Machinery Co.
158 Elliott St., Beverly, Mass.

Decitron

POST ELECTRONICS
Division of Post Machinery Co.
158 Elliott St., Beverly, Mass.

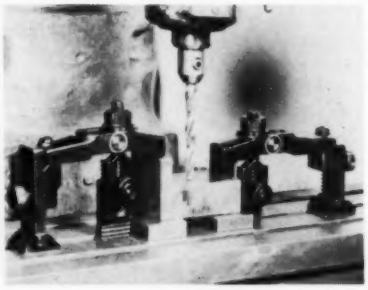
☐ Send literature on Model_____
☐ Please send name of nearest representative

Name_____
Company_____
Address_____
City_____ State_____

Circle 719 on Page 17

ward. **Humphrey Inc.**, 2805 Canon St., San Diego 6, Calif.

Circle 470 on Page 17

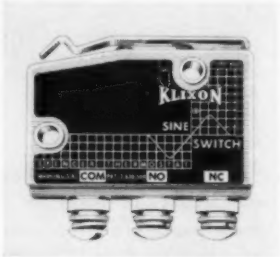


Clamp Assembly

Item 471

Device has clamping ranges of $\frac{7}{8}$ to $2\frac{1}{4}$ inches and $2\frac{3}{8}$ to $4\frac{7}{8}$ inches. Models are available with T or Stud bolt subassemblies which are interchangeable and have a patented $\frac{1}{4}$-turn serration lock feature which provides quick, safe, and accurate adjustments. Unit has no loose pieces and setup time is held to a minimum. **Hi-Lo Products Co.**, 8817 Lyndon Ave., Detroit 38, Mich.

Circle 471 on Page 17



Miniature Switch

Item 472

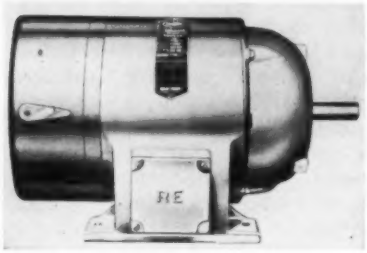
Unit is designed to operate continuously at temperatures as high as 375F. Model KX5 can withstand severe environmental conditions and is sealed with the aid of glass and fused ceramic headers. Switch is unaffected under rapid cycling from −65F to +375F within 5 minutes. Life expectancy of unit is 25,000 cycles minimum under rated load. Switch is available with auxiliary leaf, roller, or pushbutton actuators. **Spencer Thermostat Div., Metals & Controls Corp.**, Attleboro, Mass.

Circle 472 on Page 17

Brakemotor Package

Item 473

Assembly consists of an electric motor and disc-type magnetic brake. Wafer type brake reduces overall dimensions to a minimum and offers versatility in adapting to equipment. The doughnut type brake magnet permits extending the shaft clear through. It can be mounted on the input or output sides of gears or fluid couplings. Drive motors are available in NEMA frame sizes from 182 through 326U, dripproof or totally



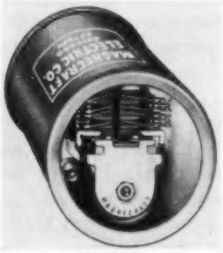
enclosed. Operating ratings of brakes are from 3 to 50 ft-lb continuous duty, and from 3 to 75 ft-lb intermittent duty. **Reuland Electric Co.**, Alhambra, Calif.

Circle 473 on Page 17

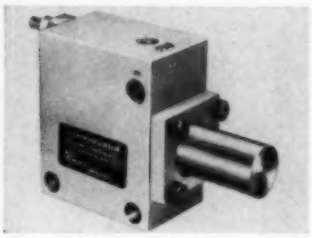
Enclosed Relay

Item 474

Observation window for visual inspection is feature of device. Enclosure is dusttight, of conventional construction with a heavy plastic insert in the end of the container. Unit can be supplied with contacts ranging from bifurcated (twin) contacts for switching extremely low voltage and low current to power contacts rated 10 amp at 115v ac, noninductive load. **Magnecraft Electric Co.**, 3354D W. Grand Ave., Chicago 51,



Circle 474 on Page 17

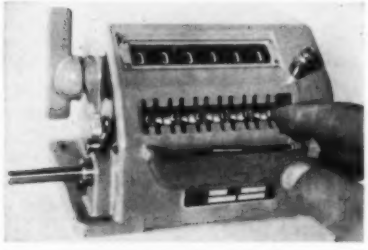


Flow Regulator

Item 475

Device is a combination bypass and restrictor type flow regulator with a built-in relief valve in a single housing. Dual unit can be used as a high capacity relief valve, as a remotely operated relief valve, for power steering, or to provide small flow for a control system. Port connections are designed for ½, ¾, or 1-inch pipe. Maximum operating pressure is 3000 psi and the relief valve is adjustable within 3 ranges: 100 to 800, 250 to 1500, and 500 to 3000 psi. **Fluid Controls Inc.,** 1284 N. Center St., Mentor, Ohio

Circle 475 on Page 17

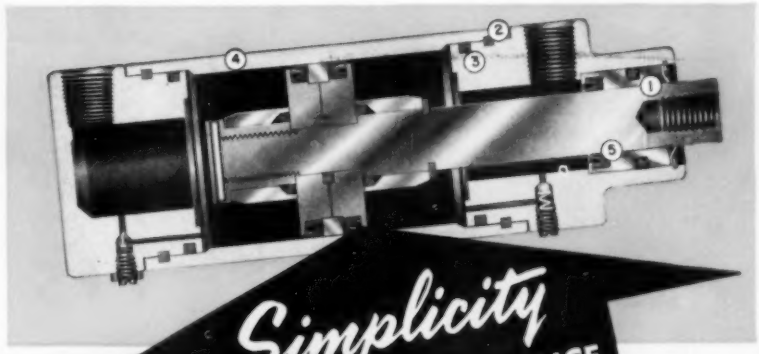


Double Counter

Item 476

Designed for controlling processes requiring a warning or deceleration signal, Model U 280-Z has two predeterminations, each independently settable to a total of 99,999 with knock-off by two spdt switches. The counters add and subtract to a maximum speed of 5000 rpm. Grip wheels under the hinged cover set the counter. Both predeterminations are simultaneously reset to zero for repeat cycling. Unit is available with optional 8-digit key reset totalizer for electrical counting, and for base and panel mounting. **Presin Co.,** 12128 W. Pico Blvd., Los Angeles 64, Calif.

Circle 476 on Page 17



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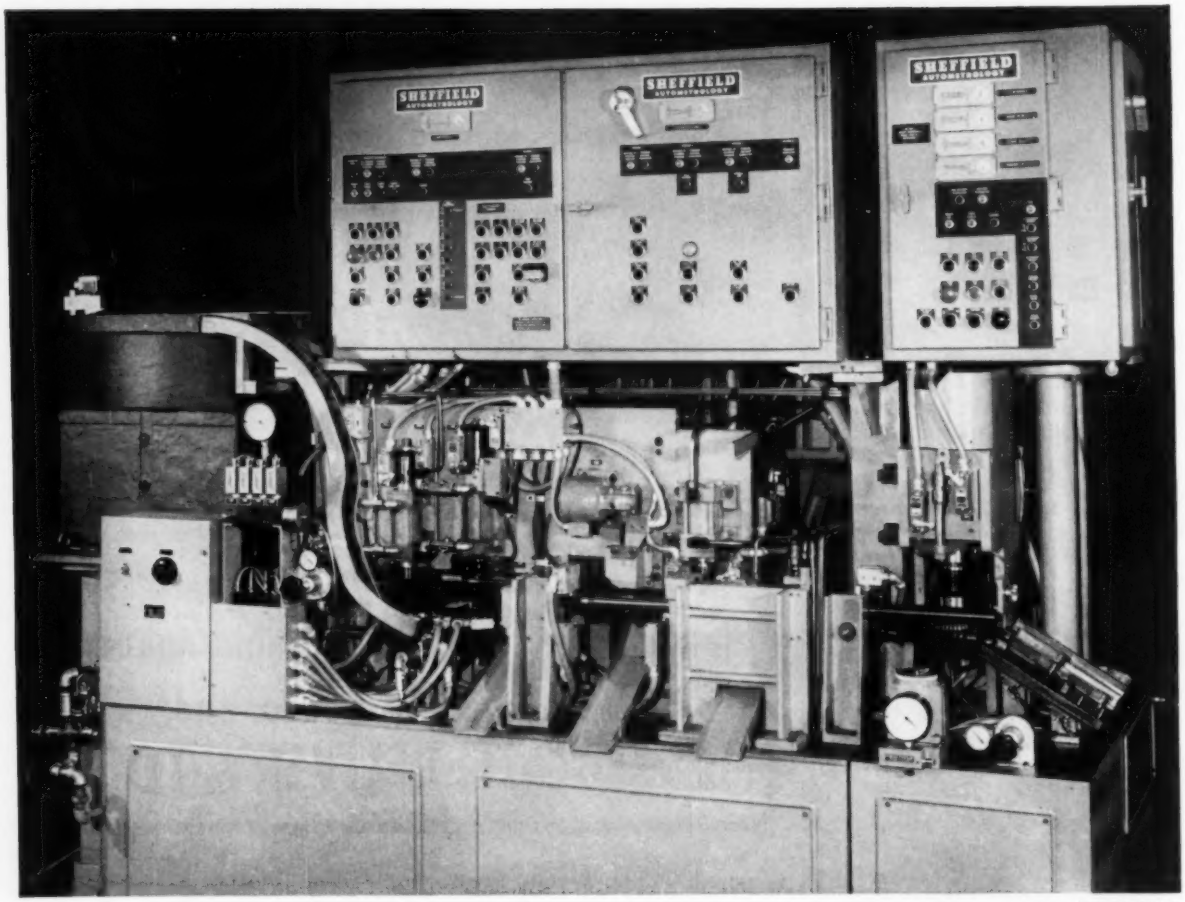
AIR CYLINDERS • AIR VALVES • HYDRAULIC CYLINDERS
ROTARY ACTUATORS • SPECIAL CONTROLS

Circle 724 on Page 17



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Tapered roller bearing components are:

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ALL AUTOMATICALLY

Eliminated are the tedious hand operations and the scrap due to errors in judgement of both inspectors and assemblers.

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manufacture and measurement for mankind

Circle 725 on Page 17

catalogs and literature

Latest automation information. For copies use card page 17.

Machine Tools

Crescent Tool & Machine Co. Inc., 1780 *Southfield Rd., Lincoln Park* 25, *Mich.*—12 *page booklet*—Line of machine tools which includes transfer machines, hydraulic index tables, multiple drill heads, hydraulic power units, and special machines from standard components is described in Bulletin 54. Electrical controls, control valves, and feed strokes of the hydraulic power unit are explained and an installation drawing of the unit included.

Circle 477 on Page 17

Automatic Turret Lathes

Gisholt Machine Co., 1245 *E. Washington Ave., Madison* 10, *Wis.*—10 *page bulletin*—Automatic ram type turret lathes with hydraulic drives are described in Catalog 1182-A. Specifications are given and operating principles explained. All operating functions are programmed from a master control drum that indexes with the turret. Illustrations of the various control units are included. Features of the machine are noted.

Circle 478 on Page 17

Compressed Air Dryers

Van Products Co., 5806 *Swanville Rd., Erie, Pa.*—12 *page booklet*—Compressed air dryers which provide moisture control are described. Functions of the dryer and its operation are noted. Specifications, dimensions, and operating capacities are listed. Action of the automatic drain valve is explained.

Circle 479 on Page 17

Plastic Wiring Ducts

Panduit Co., Dept. ANC, 10132 *S. Washtenaw Ave., Chicago* 43, *Ill.*—4 *page pamphlet*—Two types of plastic ducts for electrical control panel wiring are described. Features of the open slot and closed slot design are noted and different mounting methods are also covered.

Circle 480 on Page 17

X-Ray Instrumentation

Instruments Div., Philips Electronics Inc., 750 *S. Fulton Ave., Mt. Vernon, N. Y.*—12 *page booklet*—Engineering data on X-ray instruments for element analysis and structure determinations is given in Bulletin RC-212 5M 957. Included is brief discussion of automatic spectrograph capable of analyzing as many as 24 elements in a single sample and printing the results on a tape.

Circle 481 on Page 17

Precision Boring Machine

Jones & Lamson Machine Co., Clinton St., Dept. 710, *Springfield, Vt.*—6 *page pamphlet*—Illustrations of the various components of the boring machine are given in Bulletin 5705. Features of the spindle, table, and cross-slide are noted and specifications listed.

Circle 482 on Page 17

Overhead Handling Equipment

American Monorail Co., 13107 *Athens Ave., Cleveland* 7, *Ohio*—8 *page bulletin*—Standard equipment used for overhead handling systems is described. Automatic finishing, steel storage, plating operations, container handling and other applications are explained and illustrated.

Circle 483 on Page 17

Drives and Motors

Reliance Electric & Engineering Co., 24701 *Euclid Ave., Cleveland* 17, *Ohio*—12 *page booklet*—Integral ac motors to 400 hp, dc units to 1000 hp, dc and ac generators and motor generator sets, gearmotors and variable speed drive systems and their control are covered in Bulletin A-2400. Illustrations of engineering and manufacturing processes are included.

Circle 484 on Page 17

Resistance Thermometers

Trans-Sonics Inc., Burlington, Mass.—16 *page booklet*—Data on platinum resistance thermometers for temperature measurement, telemetry, and control are given. A tabular guide to basic types of thermometers is included.

Circle 485 on Page 17

Silicone Products

Dow Corning Corp., Midland, Mich.—16 *page booklet*—Silicone products which have a resistance to heat, cold, electricity, moisture, and chemicals are covered in Bulletin 1-113. Data on properties and performance of over 150 products is given.

Circle 486 on Page 17

Counting Instruments

Production Instruments Div., General Controls Co., 704-26 *W. Jackson Blvd., Chicago* 6, *Ill.*—4 *page pamphlet*—Electric stroke and revolution counters, electric counter actuators, coil winding counters, and automatic batch counters are covered in Bulletin AD 330. Illustration, prices, and voltages for various models are given.

Circle 487 on Page 17

Plug Guide

Cannon Electric Co., 3208 *Humboldt St., Los Angeles* 31, *Calif.*—40 *page catalog*—Line of connectors for aircraft, switching, power and industrial use is covered in Catalog CPG-3. Brief descriptions of numerous

types of plugs are given. A check list for selecting the proper plug for a specific application is also included. General data on connectors are also covered.

Circle 488 on Page 17

Honing Equipment

Micromatic Hone Corp., 8100 *Schoolcraft Ave., Detroit* 38, *Mich.*—32 *page catalog*—Microhoning process which includes automatic stock removal and size control is explained. Machines for small diameters, and medium-range diameters, long-stroke vertical machines and multiple-spindle machines are described. Applications, specifications, and work capacities for these machines are given. Company's services and aids are listed.

Circle 489 on Page 17

Flow Meters

Hagan Chemicals & Controls Inc., 323 *Fourth Ave., Pittsburgh, Pa.*—6 *page pamphlet* — Measurement and control instruments are described in Bulletin MSP-141. Features and advantages of the ring balance meter are noted and typical applications of recorders, indicators, and controllers are discussed.

Circle 490 on Page 17

Plastic Injection Molding Unit

Hydraulic Press Mfg. Co., Div. of Koehring Co., Mt. Gilead, Ohio—6 *page pamphlet*—Features of the plastic injection molding machine, Model 450-HV-20/28 are noted in Bulletin 5720. A description of the various components in the unit is given, specifications covered, and standard and optional equipment mentioned.

Circle 491 on Page 17

Heat Exchangers

Ross Heat Exchanger Div., American-Standard, Buffalo 5, *N. Y.*—8 *page bulletin*—Line of exchangers for hydraulic machinery, processing systems, and machine tools is described in Bulletin 1.1K6. Design and construction of the unit is explained and a cutaway photo of a typical exchanger shown. Dimensions and weights are also listed.

Circle 492 on Page 17

Straight-Side Presses

Niagara Machine & Tool Works, 683 *Northland Ave., Buffalo* 11, *N. Y.*—24 *page handbook*—Straight-side, automatic presses are described in Bulletin 264. Features and construction of the units are explained in detail and various components including automatic coil feed, are illustrated. Speed ranges, dimensions, and specifications are listed and a diagram of the automatic circulating oil system is given.

Circle 493 on Page 17

Dust & Fume Control

Dust & Fume Control Div., Wheelabrator Corp., Mishawaka, Ind.—24 *page booklet*—Dust and fume control with cloth filtration is discussed. Illustrative examples of this method used in the chemical, asbestos, smelting, coal cleaning, flour milling, and paint industries are given.

Circle 494 on Page 17

Pelleting Equipment

Sprout-Waldron & Co. Inc., Muncy, Pa.—4 *page pamphlet*—A Rotaircool pellet cooler and dryer with a conveying system is described in Bulletin 177. Data on the construction, operation, and installation of the unit are included. Also discussed are various machines which can be used in combination with the cooler and dryer.

Circle 495 on Page 17

Potentiometers

George Rattray & Co., Div. of Hardwick, Hindle Inc., 116-08 *Myrtle Ave., Richmond Hill* 18, *N. Y.*—28 *page handbook*—Electrical and mechanical specifications for 10 different precision potentiometers are listed. Features and applications of each model are discussed. Booklet also has a section explaining technical terminology relevant to potentiometers.

Circle 496 on Page 17

Industrial Fasteners

Simmons Fastener Corp., North Broadway, Albany 1, *N. Y.*—8 *page bulletin*—Various types of fasteners for industrial use are mentioned. Dimensional drawings, specifications, and applications are given for Link-Lock, Hinge - Lock, Spring - Lock, Quick-Lock, Roto-Lock, and Dual-Lock fasteners.

Circle 497 on Page 17

Electrical Controls

Assembly Products Inc., Chesterland, Ohio—12 *page booklet*—Versatrol electro-mechanical controls which use contact meter-relays as the principal component are discussed in Bulletin 106. Features of the unit are noted, applications given and schematic drawings of various models shown.

Circle 498 on Page 17

Automatic Flour Packer

Richardson Scale Co., Van Houten Ave., Clifton, N. J.—4 *page pamphlet*—An automatic flour packing system which consists of a triple screw type feeder, an automatic flour scale, an auger packer, and a bag sewing conveyor is described in Bulletin 0157. Drawing of the system with dimensions and illustrations of the equipment in operation are included.

Circle 499 on Page 17

Hydraulic Presses

Denison Engineering Div., American Brake Shoe Co., 1160 *Dublin Rd., Columbus* 16, *Ohio*—28 *page handbook*—Ten sizes of Multipresses with capacities from 1 to 75 tons are covered in Bulletin 120-D. Control system and control valves used in the machines are explained; specifications and performance characteristics of the different presses noted. One section describes and illustrates the Multipress accessories such as table extension, ram guides, index tables, and straightening accessories.

Circle 500 on Page 17

Sheet Feeder Attachments

Dexter Folder Co., Pearl River, N. Y.—7 *page pamphlet*—Attachments such as elevator over-travel stop, sheet forwarder cam, frame reinforcing kit, magnetic hold-up rolls, and oil-free air and vacuum pump assembly are described. Attachments bring many of the advantages of late model metal sheet feeders to older units now in the field.

Circle 501 on Page 17

Hydraulic Control of Welders

Taylor-Winfield Corp., Warren, Ohio—12 *page booklet*—Hydraulic controls which can be used with flash-butt welding machines for automatic or semi-automatic operation are discussed in Bulletin SP-4A. Advantages of the controls and principles of operation are explained. Numerous schematic drawings of control linkage and hydraulic circuits are included.

Circle 502 on Page 17

Viscosimeter

Fischer & Porter Co., 40 *Jacksonville Rd., Hatboro, Pa.*—4 *page pamphlet*—Instrument which auto-

Automatic Handling System Brings **BIG SAVINGS**

Operates Between Buildings Without Operator

A Tramrail freight-carrying van leaving one building. Building doors open and close automatically. Tramrail track is high and above interference with railroad. The entire handling system is very safe.

Operator pushes wall button to start van on its way. Van rises until it reaches Tramrail carrier on track. Then carrier hauls van to building selected.

RAIN or shine, this Cleveland Tramrail system works without complaint. Inclement weather is of no concern, because no one has to go outside to operate this system.

The Tramrail freight-carrying van travels between buildings as directed by the touch of a pushbutton. It goes up and down grades and handles materials between different floor levels.

No regular operator is needed for this type of system. Usually the time required to dispatch loads is so little that production workers can do this along with their normal duties.

Great savings are made with Cleveland Tramrail automatic handling systems. They cut handling time enormously. They operate overhead above usual floor traffic and hindrances. They save floor space. They eliminate expensive floor repairs which floor conveyances make necessary. Tramrail equipment requires far less maintenance than usually is necessary with other types of conveying equipment.

Because the dividends are large and immediate when you install a Cleveland Tramrail automatic handling system, it will be to your interest to get the facts on what Cleveland Tramrail engineers can do for you.

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Overhead Materials Handling Equipment

Write for free "Automatic Handling" booklet.

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matically and continuously measures and records the temperature and temperature compensated viscosity of liquids flowing in process piping is described in Catalog 15A100. Transmitting and receiving units are explained and a chart showing a typical temperature-compensated auto-sampling application is included.

Circle 503 on Page 17

Die Casting

Henning Bros. & Smith Inc., 91-127 *Scott Ave., Brooklyn* 37, *N. Y.*—32 *page handbook*—Data on alloy composition, temperatures, metal injection pressures, gating, venting, and quenching is given. Care of dies and machines is mentioned, and defects in castings, such as shrink holes, hard spots, and gas holes, are discussed. Ways to avoid these faults are suggested.

Circle 504 on Page 17

Wire Baskets & Racks

Wire & Iron Products Inc., 1725 *Sixteenth St., Detroit* 16, *Mich.*—8 *page bulletin*—Line of parts-handling baskets for conveying and processing production parts, is covered in Bulletin MS-57. Applications for various types of baskets are noted. Conveyor hooks, plating racks, and special purpose material handling items are also shown.

Circle 505 on Page 17

Ultra-Strength Steels

Climax Molybdenum Co., 500 *Fifth Ave., New York* 36, *N. Y.*—16 *page booklet*—Steels with yield strengths over 200,000 psi for use on heavy machinery operating at high stresses, cranes, and other materials handling equipment are discussed. Also included are technical data and various tables concerning the composition and properties of these materials.

Circle 506 on Page 17

Dripproof & Enclosed Motors

General Electric Co., Schenectady, N. Y.—12 *page booklet*—1 to 5 hp Tri/Clad 55 motors for industry is the subject of Bulletin GEA-5980. Construction features are explained and illustrated. Data on installation and maintenance are also included. Accessories available for motors are noted.

Circle 507 on Page 17

Electric Fork Lift Truck

Automatic Transportation Co., 149 *W. 87th St., Chicago* 20, *Ill.*—2 *pamphlets*—Bulletin 6501-A lists specification and performance data for Elbolift (mastless) line of electrically driven industrial trucks. Electrical, mechanical, and hydraulic features are covered. Bulletin 6503-A gives illustrations of the various components of the truck. Photos of available attachments are also included.

Circle 508 on Page 17

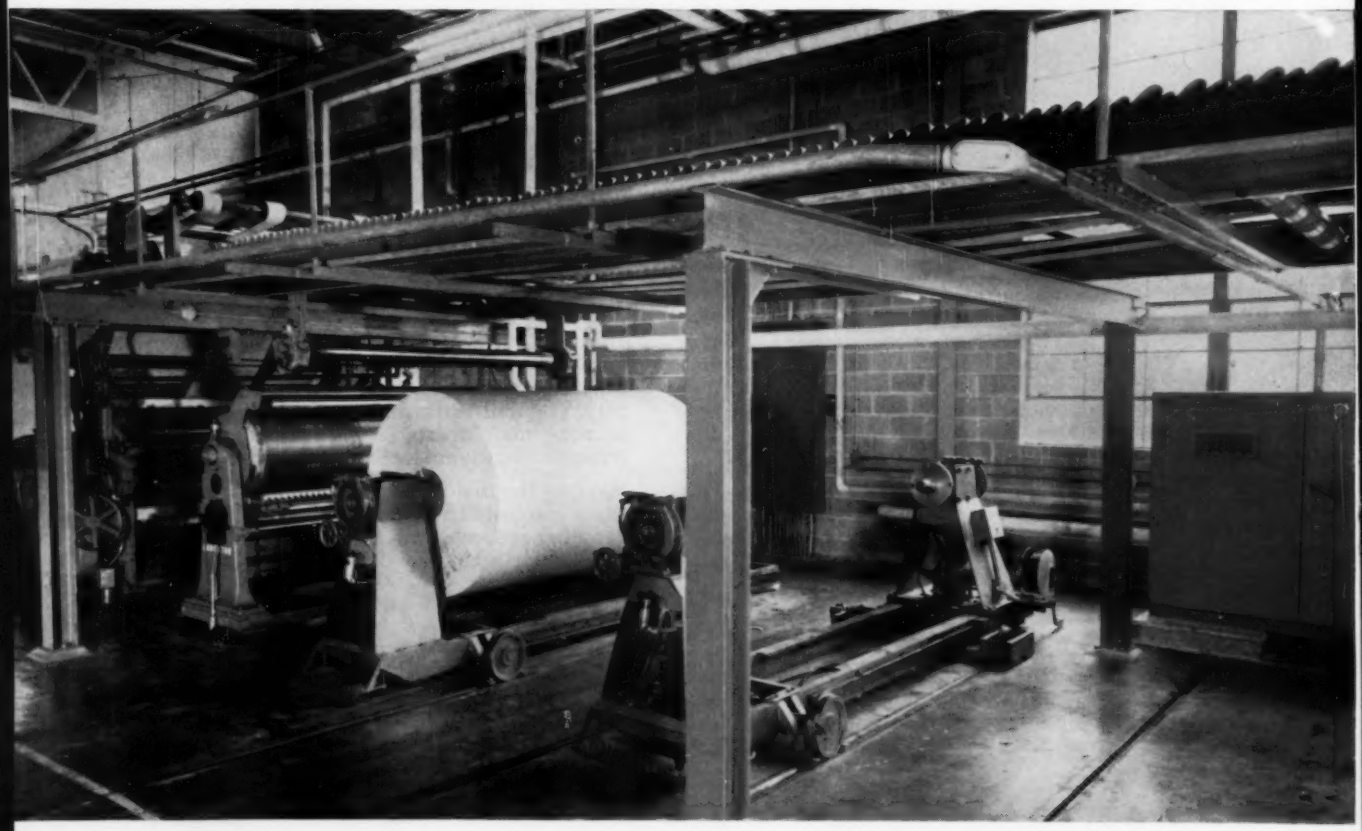
Conversion Assemblies

Press Div., E. W. Bliss Co., 1375 *Raff Rd. S. W., Canton, Ohio*—16 *page booklet*—Modernization and conversion assemblies for straight side and gap frame presses are covered in Bulletin 45. Numerous drawings show how the assembly kits convert presses from positive to pneumatic friction clutch or non-geared to single geared drive. Kits can also add more working strokes, and power slide adjustments, provide better die protection and increase operator safety.

Circle 509 on Page 17

Motor Controls

Furnas Electric Co., 1128 *McKee St., Batavia, Ill.*—56 *page catalog*—Magnetic starters, pushbuttons, drum controls, and pressure switches are covered in Catalog 5800. Specifica-



tions, applications, and ordering instructions are listed. Control arrangements for pressure switches and connection diagrams for reversing drum controllers are also included.

Circle 510 on Page 17

Gear Production

National Broach & Machine Co., 5600 *St. Jean Ave., Detroit* 13, *Mich.* 24 *page catalog*—Line of gear production equipment and broaching tools is covered in Catalog AP57-11. Machines for gear tooth honing, sound testing, gear and spline grinding, gear shaving, broaching, and broaching fixtures are described and illustrated. A chart listing capacities for shaving machines is also included.

Circle 511 on Page 17

Level Control

Instrument Div., Robertshaw-Fulton Controls Co., 2920 *N. Fourth St., Philadelphia* 33, *Pa.*—16 *page booklet*—Equipment and techniques for level measurements are described. Methods of measuring and controlling quantities and levels for various types of material are explained. Indicators, recorders, controllers, and probes are illustrated.

Circle 512 on Page 17

Metered Lubrication

Bijur Lubricating Corp., 151 *W. Passaic St., Rochelle Park, N. J.*—4 *page bulletin*—Three basic elements of automatic lubrication—lubricators, distribution systems, and meter-units are discussed. Various types of lubricators are illustrated and data on the tubing, junctions, and flexible hoses used in the distribution system are given.

Circle 513 on Page 17

Paper Tape Winder/Unwinder

Whiteford Laboratory, 420 *Market St., San Francisco* 11, *Calif.*—4 *page pamphlet*—Paper tape equipment which can be used for automatic typesetters, comparators, communications, and integrated data processing installations is explained. Operation positioning, tension, and maintenance features are discussed.

Circle 514 on Page 17

Electric Heating Units

Westinghouse Electric Corp., P. O. Box 2099, *Pittsburgh* 30, *Pa.*—24 *page catalog*—Units such as strip heaters, oven heaters, cartridge heaters, thermostats, glue and melting pots, and heater control equipment are covered in Catalog 27-620. Dimensions, voltages, and temperatures are listed, and charts for heater selection for a specific application are included.

Circle 515 on Page 17

Hydraulics and Lubrication

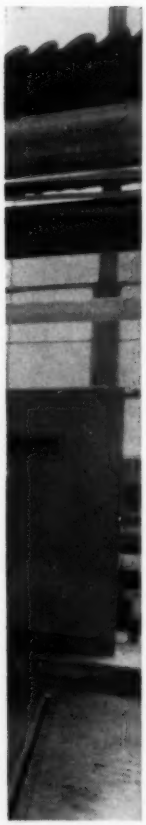
Snyder Tool & Engineering Co., 3400 *E. Lafayette Ave., Detroit* 7, *Mich.*—20 *page booklet*—General data on hydraulic system and lubrication system maintenance is given. Lubrication systems for tapping heads, drilling and boring heads, tables and slides for center column machines, and manual fixtures are explained and illustrated with photos and drawings. Hydraulic systems for transfer machines, rotary index tables, trunnion index mechanisms, and transfer bars are also described and illustrated.

Circle 516 on Page 17

Speed Control Drives

Clark Controller Co., 1146 *E.* 152*nd St., Cleveland* 10, *Ohio*—8 *page bulletin*—Packaged drives for equipment requiring adjustable speed or speed synchronization are described in Bulletin 20,000. Package includes a unit cabinet containing power conversion equipment and controls, one or more control stations and a drive motor. Components of the drive are described.

Circle 517 on Page 17



Westinghouse AV-DRIVE gives 10-second minimum to maximum corrugator capacity

Smooth, controlled deceleration is provided by a Westinghouse AV-Drive for this corrugator at the Eddy Paper Corporation. Now this unit can be slowed from 600 to 60 fpm in as little as 10 seconds, while necessary changes are being made for another order.

After a year of almost constant operation, Westinghouse AV-Drives are still giving top-notch, trouble-free performance at this installation.

Do you have an adjustable speed drive problem? Call your local Westinghouse representative, or write Westinghouse Electric Corporation, 3 Gateway Center, P.O. Box 868, Pittsburgh 30, Pennsylvania.

J-22097

POWER-UP starts with CONTROL

YOU CAN BE SURE...IF IT'S Westinghouse

Circle 727 on Page 17

AUTOMATION problem forum

Readers with problems concerning systems, equipment or components for automated operations are invited to outline them to: The Editor, AUTOMATION, Penton Bldg., Cleveland 13, Ohio. Solution suggestions should refer to case number and title of the problem involved. Dates shown with suggestions indicate issue in which the problem was presented.

Suggestions for 1274-P (Aug., 1957)
Positioning Device

. . . We have recently developed a new type step motor which we believe can be used in this case . . .

S. Noodleman
B. A. Wesche Electric Co.

♦

. . . This problem could probably be solved economically by using a fractional horsepower reversible motor driving a rack. Connected to the rack would be a potentiometer to provide an electrical measure of the position of the rack. The controlling current could be passed through a resistor and the voltage drop across this resistor compared with the voltage across the rack potentiometer by means of suitable polarized relays. When the controlling current changed, the relays would sense the difference in voltage, and energize the motor to run in the proper direction so that the rack and potentiometer would move to correct the difference.

Suitable polarized relays can be obtained from several sources. Cutler-Hammer has a transistorized polarized relay which is quite sensitive and can be obtained in varying degrees of sensitivity depending upon the accuracy required. The exact choice of method would depend somewhat upon the rate of response desired, as well as the accuracy needed. Employing relays as I have suggested involves some time lag. This could be avoided by direct operation of the motor through suitable magnetic amplifiers although this scheme would involve greater expense. We have equipment available which will perform in this manner . . .

W. L. Hampton
Cutler-Hammer Inc.

♦

. . . Enclosed is our standard catalog which covers ac solenoids. It is possible to use ac solenoids on dc application with a calculated figure with dc giving them twice the pull current as that of ac. If the party who is interested would review our catalog and fill out the enclosed data sheet, we will be happy to send him a sample of the unit which we feel will fill his requirements . . .

Ben Roman
Dormeyer Industries

♦

. . . I believe that we have a device in our Hysteresis Torquer line which will solve his problem. Our Torquers are devices which will transmit even torque at a given control current, regardless of the speed or other environmental operating conditions surrounding it. This characteristic makes them useful where the torque output of the clutch could be used to balance against the resistance of a spring or against the swing of a known counterweight to give an indication of position according to current input.

John E. Traise
Magtrol, Inc.

♦ ♦ ♦

Suggestions For 1064-P (July 1957)
Detecting Metal in Hay

. . . We have several types of metal detectors and literature is enclosed. We would very much like to learn more details of the application so that we could submit a specific recommendation and quotation. . .

R. Tobert
Dings Electronics Inc.

♦

. . . We are enclosing descriptive information on our Model TM Metal Detector but in order for us to quote on the proper equipment it is necessary for us to have complete application information. . .

E. Franz
J. W. Dice Co.

♦

. . . Reference is made to a metal detector which is described in the enclosed brochure. . .

L. D. Singer
Radio Corp. of America

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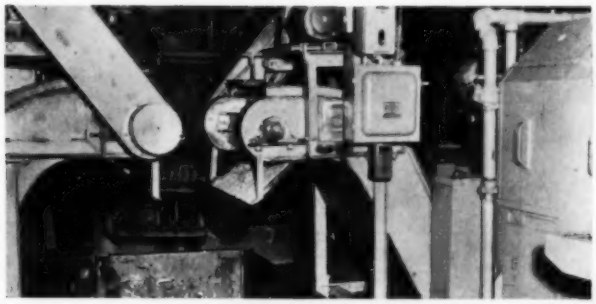

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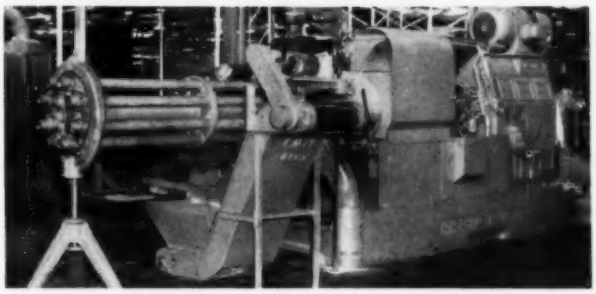
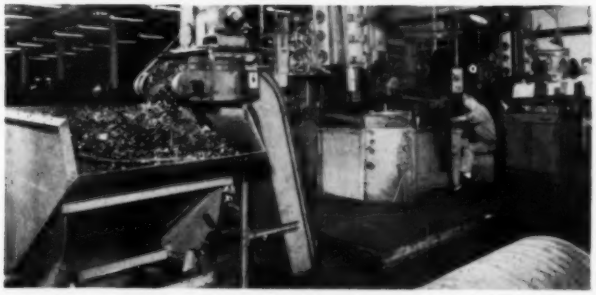


CONTINUOUS SCRAP REMOVAL



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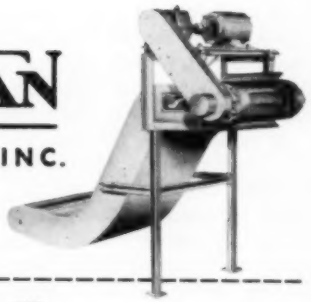

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Circle 729 on Page 17

AUTOMATION abstracts

ELECTRONIC CONTROL RELIABILITY

By HARRY L. PALMER
Manager Eng., Specialty Control Dept.
General Electric Co.

RELIABILITY of equipment is normally expressed as the probability of the equipment performing adequately for a specified period of time. In this paper, reliability is considered as the percentage of normal production time that the equipment is maintained in an operating condition. Downtime is the percentage of time that the equipment is inoperative because of a failure of any kind.

A number of factors can affect the reliability of an electronic machine control. These are the ones that are considered to be of most importance: 1. Electrical design. 2. Mechanical design. 3. Operating environment. 4. Maintenance practices. 5. Components, including contactors, relays, and electronic tubes.

Electrical Design

The circuit tolerance or the factors of safety provided in signal and operating voltages can have a considerable bearing on the initial installation and the necessity for readjustment of electronic equipment. This is considered separately from component tolerance. The electrical designer is definitely responsible for the reliability of the control he is designing because it is in his power to provide adequate tolerances in the equipment. This situation is sometimes aggravated by the use of marginal components that do not permit the use of adequate safety factors in the circuit because of possible overloading or exceeding their operating range.

It is also the responsibility of the electrical circuit designer to specify operating levels for the components that are far enough below their ratings to avoid component failures due to short life. Many of the components used in industrial electronic equipment must be adopted from the communications industry. In many cases these components have published ratings in line with appreciably shorter life than can be tolerated in industrial equipment. The electrical designer must take these factors into consideration when selecting components to insure adequate life of the equipment.

Many of the components used are manufactured under wide tolerance specifications, and therefore the circuit design must accommodate these wide tolerances, or the components must be selected to suitable tolerance limits. In addition to the deviation from rated values, many components will change their characteristics appreciably with temperature or other operating conditions.

It is usually the electrical designer who is responsible for the instruction book. This is an important item in keeping the equipment in service under normal maintenance problems.

Mechanical Design

The mechanical design of an equipment can also play an important part in its reliability. From the maintenance point of view, accessibility of all components is essential. The design should permit removal of any component without completely dismantling the control. Most industrial users of electronic equipment recognize the fact that the layer type of construction employed in many radio chassis offers a severe handicap to the maintenance man.

The method of assembly has a bearing on reliability. There is considerable disagreement on just what is the best type of construction. For example, some manufacturers and some users feel that the only reliable electrical connection is a soldered joint. Others have found that the only type which can be depended on is one involving screw type terminals with lock washers. There is also considerable disagreement on the use of plug-in subassemblies. Some feel that the ability to sectionalize the equipment and remove functional subassemblies for repair and replacement is essential to reliability. The experiences of others are such that they look with distrust on any unnecessary sliding or pressure contacts. There are also those who favor the encapsulation of groups of components, while others flinch at the idea of having to replace a subassembly because some small inexpensive component has failed.

Environmental Factors

The mechanical designer as well as the electrical designer must take into account the effect of environmental conditions such as dirt, atmospheric contaminants, and temperature. If the equipment is not given adequate protection from these adverse operating environments, the equipment will surely be unreliable. Many times it is exceedingly difficult for the mechanical designer to get information on these operating conditions. The machine tool manufacturer and the user have a definite obligation to the designer to acquaint him with these conditions.

Dust and dirt are probably the most commonly

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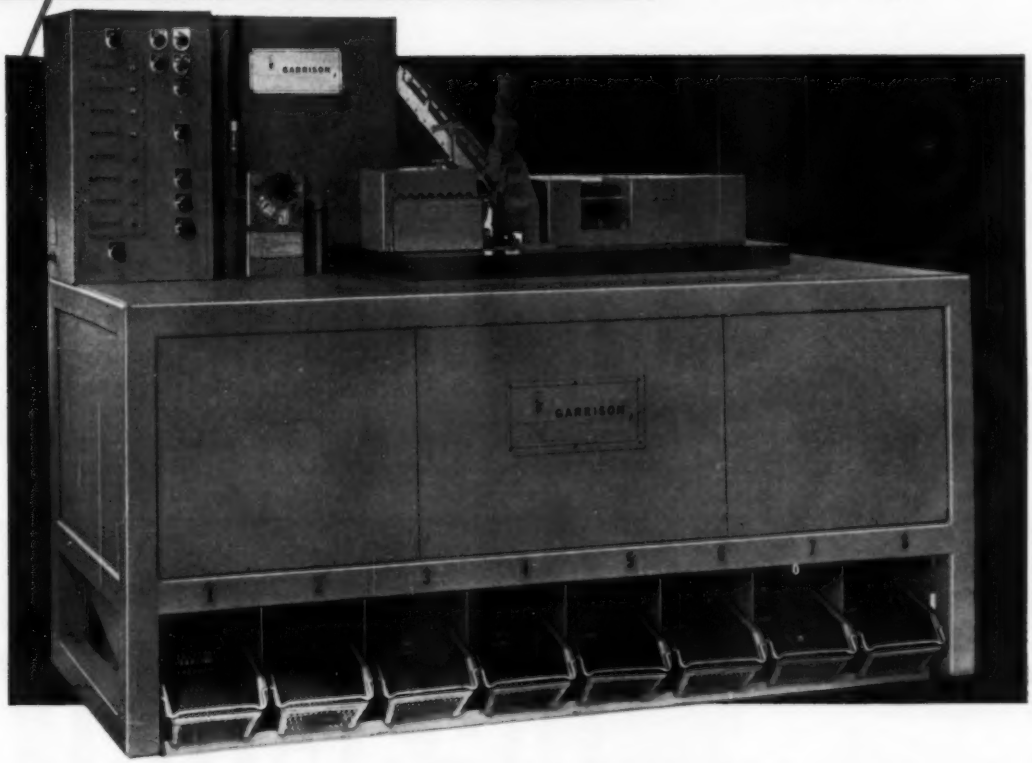

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encountered difficulties. Nonconducting particles theoretically would not cause any difficulty with static equipment, but they can have considerable effect on the bearings and other moving parts of contactors and relays, as well as mechanical accessories. Dust and dirt combined with moisture offer a very serious electrical leakage problem, especially in the case of high impedance electronic circuits. It is possible to operate with much closer spacings under laboratory or clean conditions than in an industrial plant for this reason. It is up to the mechanical designer to protect his equipment and still meet the machine builder's or user's space requirements. Therefore, his ingenuity in accomplishing this will affect the reliability of the equipment.

Temperature is often a cause of trouble in an electronic control if the control has not been designed for the temperature or the temperature variations encountered. Mercury vapor thyratrons have both high and low temperature limitations, and the trend has been away from mercury vapor to other gases that have a wider operating range. Tubes are not the only components that are affected by either high or low temperatures. With some components the life will be affected, while in others the characteristics will change and necessitate readjustments.

Shock and vibration are operating conditions that can be taken care of by the designer if he is advised as to the needs. There are a number of ways in which difficulties from these causes will show up: Electrical connections may be broken, components may fall off due to loosening of fasteners, short relay life may occur with some designs of relays, and certain tubes may give short life. Shock, vibration, and general mechanical abuse can affect the reliability of controls unless these operating conditions have been made known to the designer, and he has done a good job in designing equipment in accordance with the requirements.

Equipment Maintenance

When we express reliability as the percentage of the operating time that the machine is available for productive work, it is obvious that maintenance plays a big part in keeping the productivity percentage high. Maintenance, of course, is a job for humans and can only be accomplished by adequately trained personnel. There are many ways in which this training can be acquired. Large companies often operate their own training schools. Some manufacturers run maintenance training schools for particular types of their equipment. Some communities have adult education programs that include electrical maintenance classes, and these are particularly valuable in communities where large manufacturing companies are able to supply trained personnel as instructors.

After the maintenance man finds the difficulty to be the failure of a component, he must have replacement components available, otherwise valuable time will be lost before the control can be put back into

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service. Most manufacturers supply lists of recommended spare parts, and from these lists, it is possible to build up stocks that will facilitate rapid servicing. Experience has proved that an investment in the right spare parts will be repaid many times by increased production.

Component Reliability

Assuming the circuits have been designed correctly, and the equipment is packaged for operation and environment, next concern is for the components.

Resistors are a very common circuit element. They are found in many forms, from a large cast iron grid to a small ribbon of carbon deposited on a printed wiring board. This particular component is a static element, and assuming that it has been manufactured correctly and operated within its rating, it should never fail. Although it might have a temperature characteristic that would be detrimental to the operation of the equipment, this should be the consideration of the designer and not the maintenance man. However, abnormal circuit conditions can cause unexpected overloads and consequently, burnouts. For this reason resistors should be an item in the spare parts stocks.

Capacitors are another circuit element commonly used in electronic controls. These can range in form from two small pieces of tin foil separated by a piece of mica to a large oil filled unit used for energy storage or power factor correction. Capacitors are also static elements that, if used within their rating and manufactured correctly, should have practically unlimited life. There is one possible exception however, and that is electrolytic capacitors which use a chemically formed insulating film that may deteriorate with age or adverse temperature conditions. Due to the fact that the failure of other components in a circuit may subject a capacitor to operating conditions beyond its rating, these should also be stock items.

Transformers and reactors are made up of iron laminations, insulation, and copper wire. They can be designed for almost any life depending on the type and form of insulation used and the operating conditions to which it is subjected. Thus, we have a static element which can easily be designed for very long life, but which for practical and price considerations is usually designed for limited life. Usual industrial transformers have a minimum life of 20 years. One thing that can shorten this life however is excessive operating temperature. Except for hermetically sealed and encapsulated transformers, moisture can also cause shorter-than-planned life. In fact, excessive moisture can cause instant failure. These comments apply equally well to saturable reactors for magnetic amplifiers, and can be summed up by stating that transformers and reactors are exceedingly reliable except when subjected to operating conditions not planned for by the designer.

Metallic rectifiers are components used for power supplies and as the rectifying element of magnetic amplifiers. They also have a designed life because the life of a given rectifier depends on its rating. Some rectifiers designed for military applications are

Absolute control!

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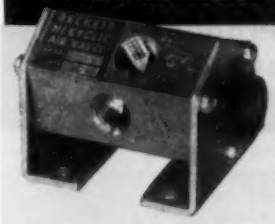

Model B Beckett Hi-Cyclic Air Valve. Also made in two springloaded styles —Model BB ball point for cam operating, Model BSL for straight line actuation. Spool end nuts, or optional exhaust type speed controls may be used for velocity adjustment.

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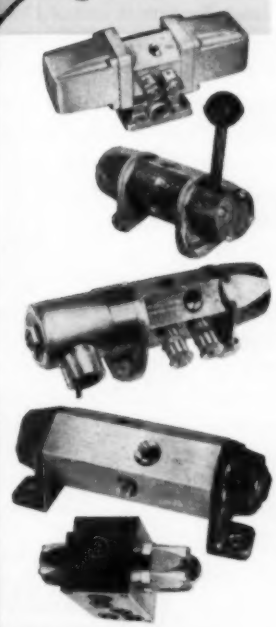

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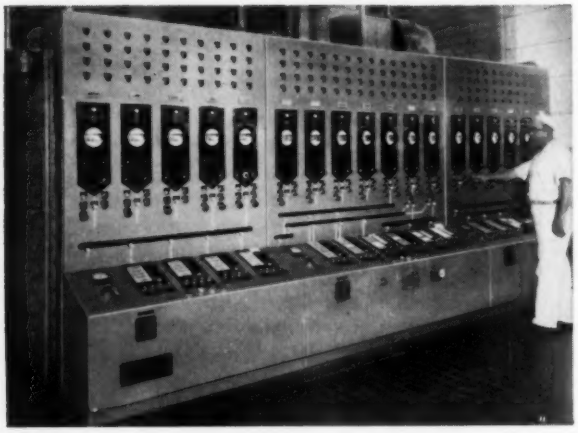

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deliberately rated to give only a few thousand hours life because that is all that is expected of the equipment. However, units designed for industrial use are rated to give much longer life. Rectifiers have the advantage that their condition can be checked at any time and therefore their life limit can be predicted. Thus they can be replaced on schedule to avoid downtime. This is in contrast to many types of tube rectifier failures which cannot be predicted as accurately.

Semiconductors, both diode and transistor types, are the hope for the electronic design engineer. Theoretically these devices operate without deterioration and therefore have infinite life. However, production methods that will insure perfect elements have not been developed to date. Therefore, none of the transistors and diodes on the market today have infinite life. Due to their relatively high current rating and their small physical size, they have a low thermal capacity. However, these difficulties will eventually be overcome, and semiconductors are considered to be the most promising components for reducing the size and increasing the reliability of electronic controls.

Even though we are discussing electronic control equipment, it is practically impossible to avoid the use of some relays and contactors in controls. These devices are far from being trouble free as they exist today. The principal problems with relays and contactors used with electronic equipment are their life limitations and the uncertainty of controlling low energy circuits with contacts that open and close in free atmosphere. One hope in this area is the adoption of hermetically sealed relays, such as those designed for aircraft purposes.

High-vacuum control tubes of the receiving tube variety are used in great numbers in electronic control circuits. These components have many staunch supporters as well as many critics who are preaching their abolition. This is understandable because there are many tubes designed for many purposes and many ways to use these tubes, some of which are definitely wrong. The old full-size radio receiver tubes manufactured in large quantities on automatic machines were, and still are, sold for very reasonable prices. Because of many failures caused by misuse and misapplication, they are distrusted by many plant service and maintenance people. Due to automatic production and close quality control, these tubes are remarkably reliable considering their price. There is considerable data to indicate that if a tube of this type has operated for 15 to 30 days in a given application, it has a high probability of lasting from 3 to 5 years if undisturbed and not subjected to abnormal operating conditions.

Another misconception is that it is economical to turn off tube filaments when equipment is not in use. Tests prove that tubes will frequently last longer and retain more consistent characteristics if their filaments are operated continuously. Those of you who use computers have probably learned that lesson. If not, you should try this practice, and you will have much better tube life and more consistent results from your computers.

Miniature tubes have been designed as a result of the pressure for small size in military communication

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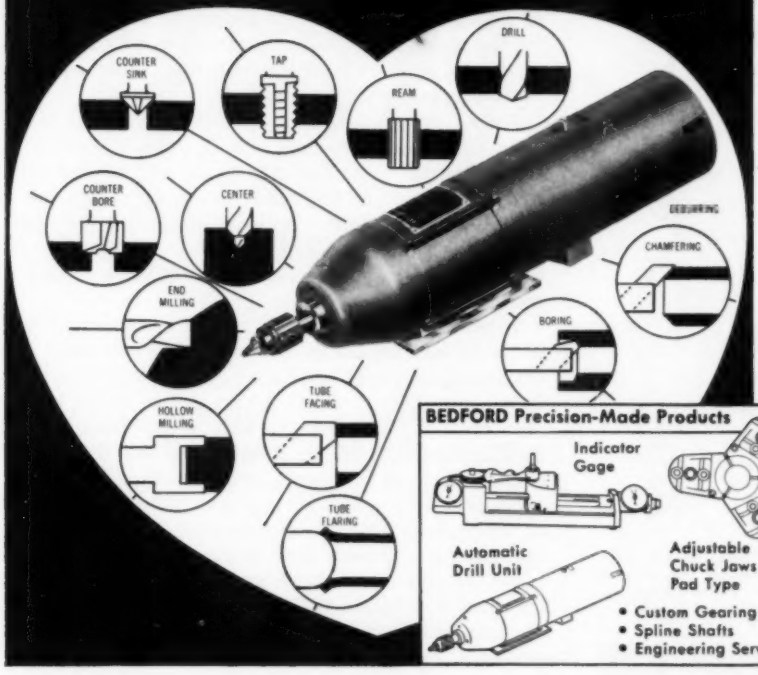

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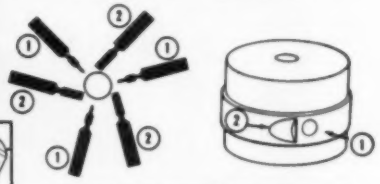

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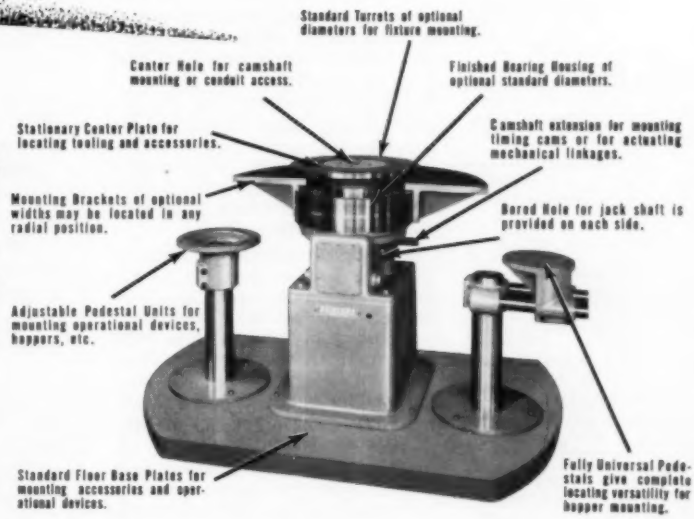
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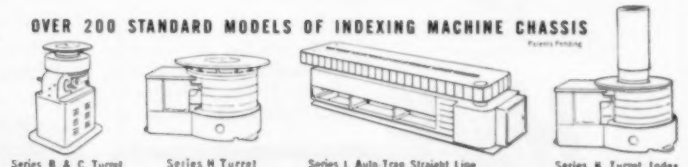

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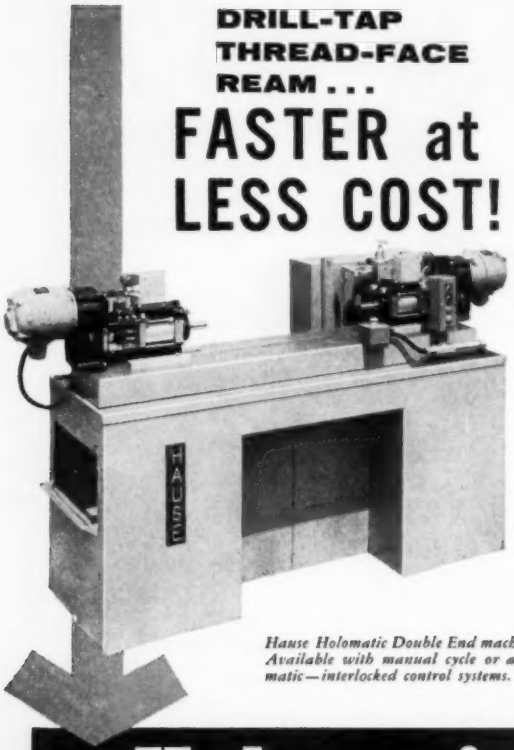

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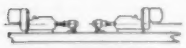
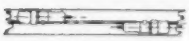
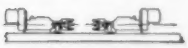


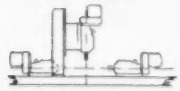
With External Tool Supports for Boring



Off—Set



With Multiple Spindle Heads



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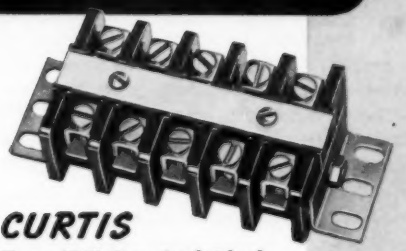

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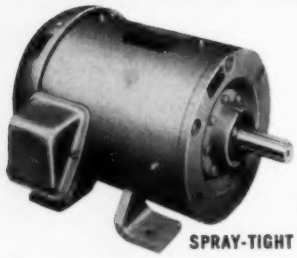

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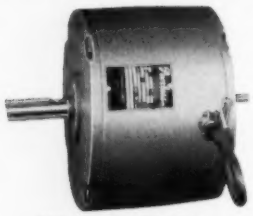

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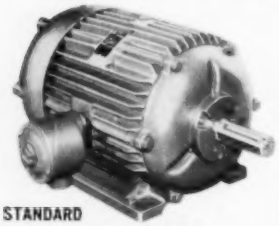

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has in his plant 1500 vacuum tubes and about 140 gas filled tubes. His maintenance data indicates that machine downtime for any cause is somewhat less than 10 per cent. About half of this total time is for electrical maintenance. An analysis of his electrical downtime shows that 40 per cent is to replace components such as relays and contactors. Approximately 30 per cent is spent in readjusting the controls to take care of variations with temperature. He has not differentiated between vacuum tubes and gas-filled tubes, but states that 30 per cent of electrical downtime is applicable to tube failures. However, he feels that he must allow more maintenance time on electronic controls than on magnetic controls.

The papermaking trade association has completed a reliability study on drives for paper mills. This study covers 29 paper machines located in 9 mills. Of these paper mills, 18 have electronic speed drives and 11 have mechanical speed controls. The downtime for all of these paper machines averaged 5 minutes for every 24 hours of operation.

Downtime was analyzed as follows: Motors and generators accounted for 22 per cent. Draw variations, which can be classified as difficulties with the paper machines, accounted for 17 per cent. Regulator readjustments accounted for 10 per cent. Wiring grounds in the electrical system accounted for 9 per cent. Relays and contactors accounted for 8 per cent. Rheostats and potentiometers accounted for 6.5 per cent. Overload tripping accounted for 6 per cent. Electronic tubes, and these would be primarily vacuum tubes, accounted for 4.5 per cent. Regulator components accounted for 4 per cent. Tachometers used to measure the speed of the drive accounted for 2.5 per cent. The simple pushbutton even accounted for 1.5 per cent, and other mechanical components accounted for 1 per cent, with 8 per cent unclassified.

There are several conclusions that may be drawn from these examples of field experience: 1. The large amount of lost time chargeable to readjusting controls is a challenge to control equipment designers. 2. The amount of time chargeable to component failures shows that the designer must be more careful in selecting components, and there needs to be a better understanding of actual operating conditions. In some instances, there needs to be a unified demand for better components. 3. Electronic tubes account for a relatively small amount of downtime.

From a paper entitled, "Reliability of Electronic Machine Controls" presented at the AIEE Machine Tool Conference, Milwaukee, Nov. 1957.

CORRECTION

In the abstract entitled "Design for Manufacture," which appeared in the December 1957 issue, an editing error occurred in the last sentence on p. 144 and first sentence on p. 145. These should read: "The cost of the equipment to manufacture 110 bearing caps of the second type per hour was 45 per cent greater than the cost of the equipment to manufacture 180 bearing caps of the first type per hour. Much of this additional cost can be attributed to the design of the second type of bearing cap."

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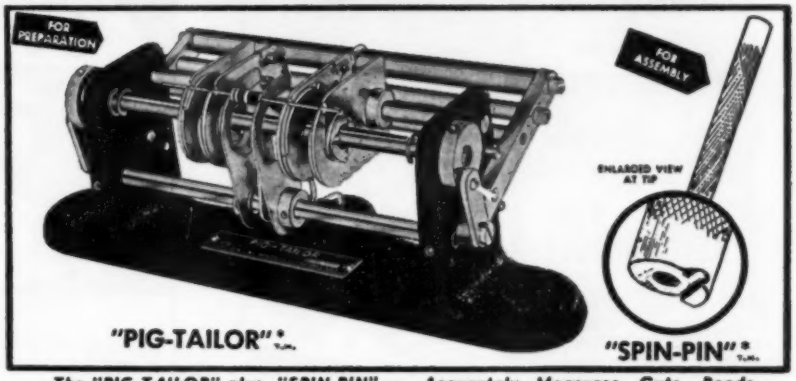

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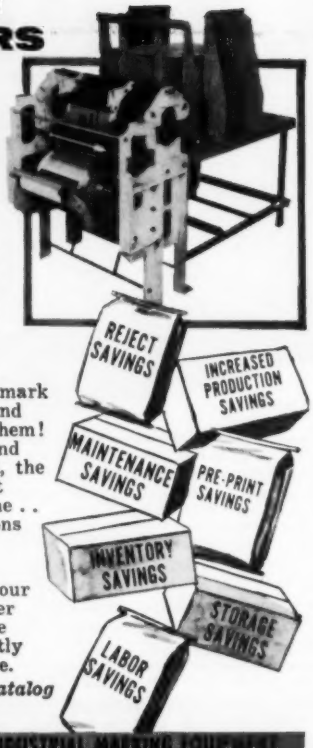

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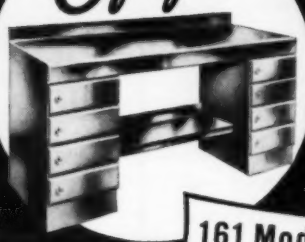

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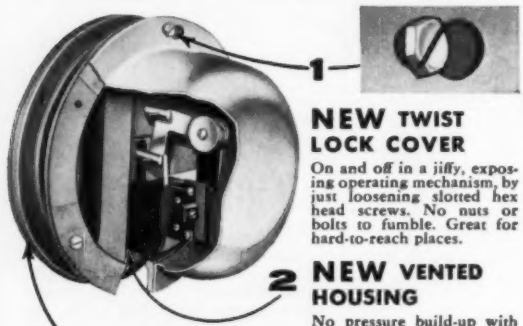

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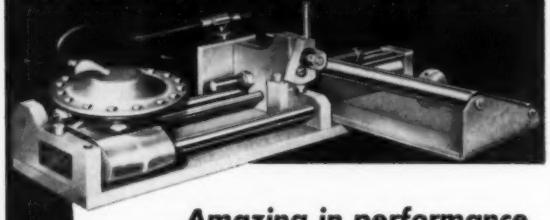

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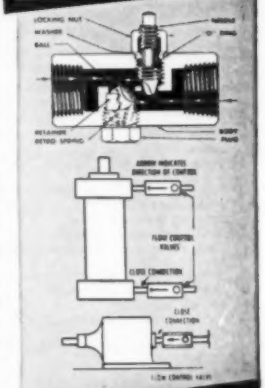

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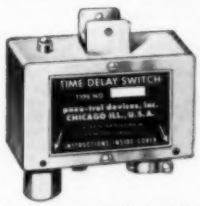

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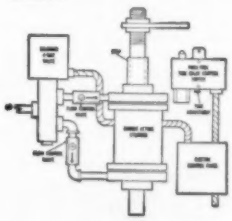

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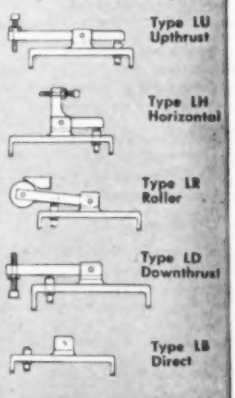

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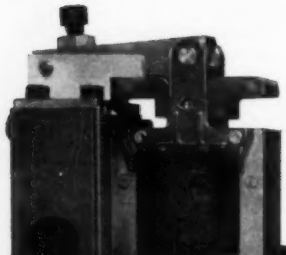

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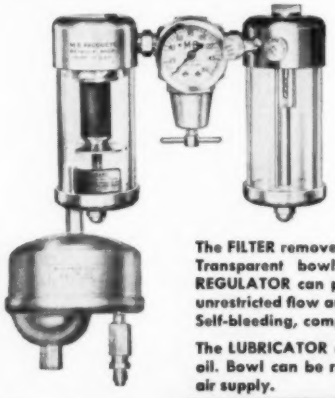

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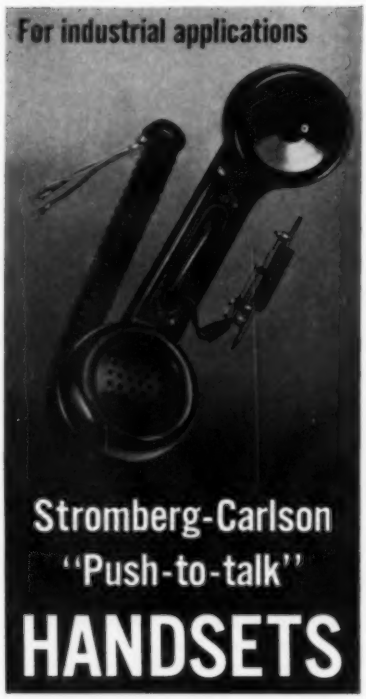

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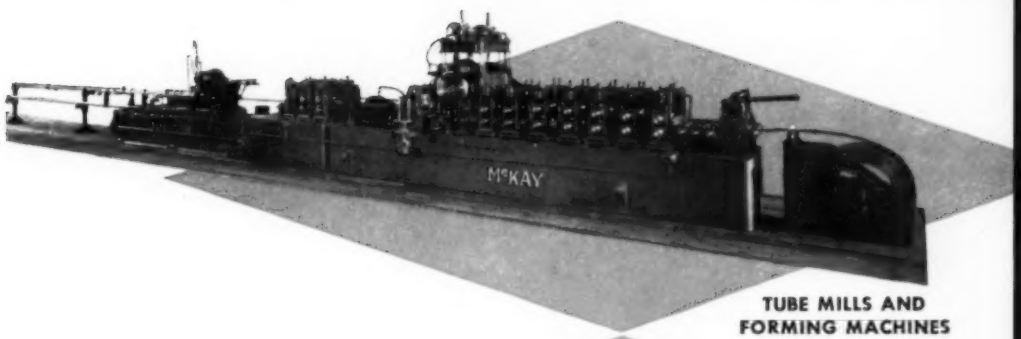
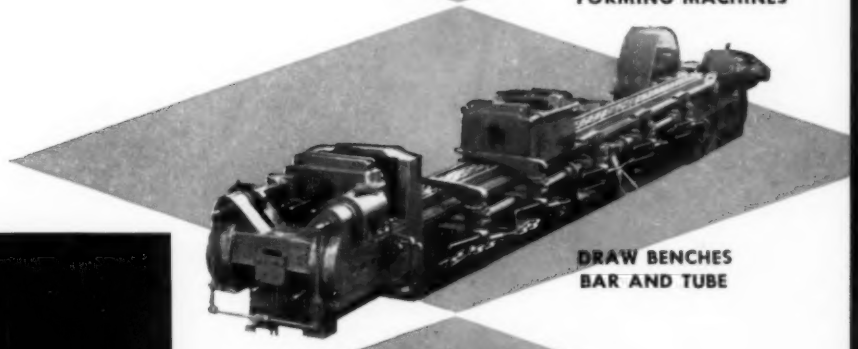
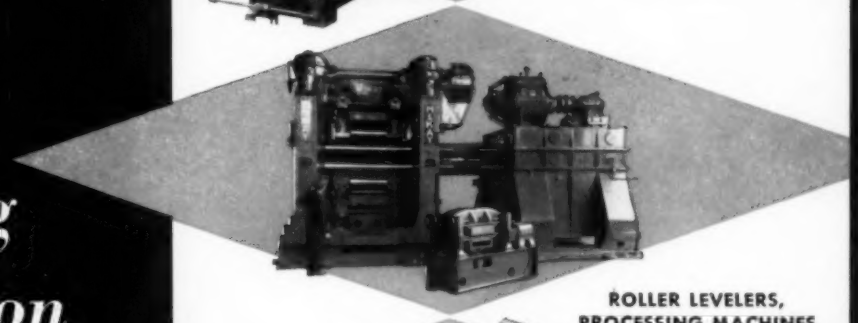


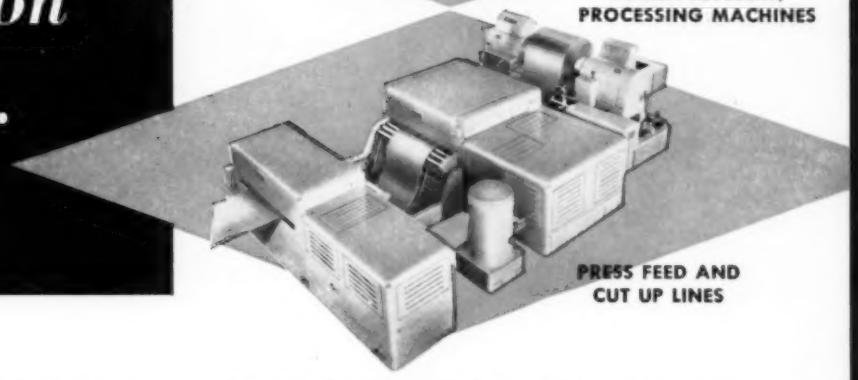
TUBE MILLS AND
FORMING MACHINES



DRAW BENCHES
BAR AND TUBE



ROLLER LEVELERS,
PROCESSING MACHINES



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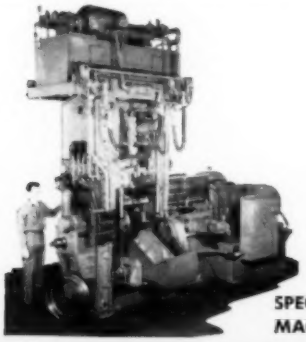

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